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# The Technique and Value of Project Teaching in General Science

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## CHAPTER I.

### BACKGROUND FOR THE EXPERIMENTAL EVALUATION OF PROJECT TEACHING IN GENERAL SCIENCE.

#### 1. PURPOSE OF THE STUDY.

The purpose of this study is threefold: (1) to determine, as far as is possible in a single limited investigation, the value of project teaching[1] in the general field of education; (2) to determine, more specifically, what values the students who carry out series of general science projects secure in comparison with the values which students secure in general science classes while carrying on traditional school activities, such as memorizing text material, reciting, listening to the teacher, watching demonstrations and working out laboratory problems; (3) to determine, upon a basis of actual classroom experience, a workable technique for teachers who are attempting to help boys and girls of junior high school age carry out worth-while projects in general science.

The need for experimentation of the kind which is described here has developed as a result of the introduction into educational discussion of a new idea concerning the type of activity which should occupy the student's time in school, or at least, the introduction into such discussion of a new term for a somewhat older idea. The project idea has not only occupied the center of attention in recent educational literature, but it has affected

1 The terms project teaching, project, project work, project study, project method, and others, are used in current discussions. In this study no distinction will be made in these terms until defined on pages 242-245. The term, "project idea." will be used to cover the general idea back of the discussions carried on under all of these terms.

some changes in school work.[2] The discussion of the advantages and values of the project idea has been conducted for the most part upon the basis of opinions of educational reformers, for example, W. H. Kilpatrick,[3] upon the basis of certain implications of modern psychology, as for instance the learning through doing concept of John Dewey, and upon the apparent values which certain teachers who have tried project work in their classes claim to see.[4] There is little direct evidence that the values claimed for project work are attained, or even that students engaging in this type of activitiy grow as much as the students engaged in the more traditional school activities. What is needed is an evaluation in terms of experimental evidence, and this evidence must be of the comparative sort. Perhaps the teachers who have "tried out projects" without controlled comparison have been merely carried away by their own enthusiasm for a popular doctrine, the latest educational fad. The need for concrete experimental evidence has called forth this study.

There is no attempt to add anything to the field of knowledge in natural science. This study will not add to the field of physics, chemistry, botany, zoology, nor any one of the special sciences. There is no attempt to determine the place of any of these sciences in the school curriculum. The place of general science, the field of experimentation for this study, is assumed, since it is now well established in the curricula of many schools.[5]

2 Heald, "The Project in Agricultural Education." G. S. Q. 1, pp. 166-169.
Hofe, "Giving the Project Method a Trial," Sch. Sc. and Math. 16, pp. 765-767.
Hosic, "An Outline of the Problem-Project Method" Eng. Jour., Nov. 1918, pp. 599-602.
Kilpatrick, "Theories Underlying the Experiment." T. C. R., March, 1919, pp. 99-106.
Meister, "Science Work in the Speyer School." G. S. Q. 2, pp. 429-445.

3 Kilpatrick, "The Project Method." T. C. R, Sept. 1919, pp. 319-335.

4 Hofe, "General Science is Project Science." Sch. Sc. and Math. 15, pp. 751-757. "Giving the Project Method a Trial." Sch. Sc. and Math. 16, pp. 765-767.
Moore, "Project Science, Progressive." Sch. Sc. and Math. 16, pp. 686-690.
National Society for the Study of Education, "Twentieth Yearbook," 1921, Part I.

5 As early as Nov. 12, 1914, the "Missouri Society of the Teachers of Science and Mathematics" adopted a committee report recommending the introduction of general science into Missouri high schools.

There is no desire to enter into the controversy of J. G. Coulter, R. A. Millikan, O. W. Caldwell, W. L. Eikenberry, F. D. Barber, and others, concerning the relative value of general science as a school subject. The chief problem here is to determine in part the educational value of the project as a type of activity of boys and girls of junior high school age.

Classes in general science were chosen for experimentation for the following reasons: (1) Teachers and educational writers have been particularly clamorous concerning the value of projects in the field of general science.[6]. (2) The subject-matter of elementary natural science was more familiar than any other school subject offered in the junior or senior high schools. (3) Considerable experience as a teacher of general science made experimentation in that field easier than in any other. (4) Direct control, as supervisor, of classes in general science in the University High School, facilitated experimentation in such classes.

The determination of a workable technique for teachers was not included in the original plans. When, however, an attempt was made to get at actual values of project work by comparing the results with students doing two types of work, it was found

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See Bray, "A Study of Science Teaching in Missouri High Schools." Sch. Sc. and Math. 15, pp. 685-689.

Also Caldwell, "Central Association of Science and Mathematics Teachers: Report of the Committee on a Four Year High School Science Course," Sch. Sc. and Math. 16, pp. 393-399.

Miller, "A Survey of the General Science Situation in Illinois" Sch. Sc. and Math. 18, pp. 398-406.

Rusterholtz, "The Present Status of General Science in the High Schools of Pennsylvania." G. S. Q. 1, pp. 223-232.

Worun, "General Science in Michigan." Sch. Sc. and Math. 19, pp. 136-149, and G. S. Q. 2, pp 267-284.

6 Kilpatrick, "Project Teaching." G. S. Q. 1, pp. 67-72.

Mann, "Project Teaching." G. S. Q. 1, pp. 13-14.

Moore, "Project Science, Progressive." Sch. Sc and Math. 16, pp. 686-690.

Sharpe, "The Project as a Teaching Unit." G. S. Q. 4, pp. 343-350.

Snedden, "The Project as a Teaching Unit." Sch. and Soc. 4, pp. 419-423.

Stevenson, "The Project in Science Teaching." G. S Q. 3, pp. 195-209.

Twiss, "Principles of Science Teaching," pp. 419-428.

U. S. Bur. of Educ., "Reorganization of Science in Secondary Schools." Bul. 1920, No. 26, pp. 16-19.

Wake, "The Project in General Science." Sch. Sc. and Math 19, pp. 643-650.

Woodhull, "The Aims and Methods of Science Teaching." G. S. Q. 1, pp. 249-254. "Projects in Science." T. C. R., 1916, pp 31 ff.

For additional evidence of the same sort see appended bibliography.

necessary to furnish directions on how to proceed to teachers of the "project groups." There was no traditional technique, no well-crystallized procedure, as is the case where students memorize text material, recite, listen to the teacher, and follow stereotyped laboratory directions. The problem became quite clear-cut. If the students work at projects, what is the teacher to do? This had to be determined in order to carry on "project groups" from which comparative data could be collected. If the value of project teaching is found to be positive, this subproblem of technique may be of even greater practical value to teachers than the more fundamental problem of the determination of the value of the project as a type of student activity.

2. THE PROJECT IDEA—SUMMARY OF CURRENT DISCUSSION—INTERPRETATION IN THIS STUDY.

What is included in the project idea? What is back of the popular discussion and experimentation current in the educational world? What is behind this widespread movement for change in school activities? The condition in which school workers find themselves at present is not altogether new. It is a recurrence of the old revolt of the reformers against traditional modes of behavior. Pupil activities, educational methods, and the content of the school curriculum, like phases of other social institutions, often fail to keep pace with the changes in surrounding social life. The consequent maladjustment, the failure of the institution to carry out its proper function, finally becomes felt. The leaders and reformers are the first to see this maladjustment. They immediately begin destructive criticism in order to make the rest of the population aware of the condition. For several generations there has been much criticism of our public schools on the grounds that they do not properly prepare students to meet immediate life conditions.[7]

More recently constructive programs for improvement have been offered. There is a large and, at present, rather widespread movement for the reorganization of the whole curriculum. There is the movement towards "minimum essentials." Problem methods of teaching are proposed. Supervised study is offered as a means towards securing better results. Certain

7 For a summary of such criticism see Meriam, "Child Life and the Curriculum," p. 39-107.

experimental schools have offered new curricula as the solution. The project is offered as another constructive remedy for certain defects in our present school education.

Among the specific defects in education which projects are supposed to remedy, are these:

1. The failure of the school to utilize the normal out-of-school activities of people.
2. The failure of the school to sufficiently stimulate students to reflective thinking.
3. The failure of typical school training in sufficiently modifying the conduct of students.
4. The failure in school practice to take advantage of the chief contribution of modern psychology, that individuals learn through their own activities.[8]

It is proposed by the advocates of the project idea to remedy these defects by a change in the type of school activity in which young people engage. It is proposed that instead of the traditional school activities, such as reading assigned lessons, reciting what is remembered of these, listening to fellow students recite, listening to the teacher, solving stereotyped and artificial problems, that students *do* something which will operate towards the working out of their own immediate problems and purposes. Kilpatrick calls this type of activity "whole-hearted, purposeful activity."[9]

The current interpretation of the project idea is readily shown by reference to the following definitions quoted from representative exponents of the idea: "The project is considered to be an act carried to completion in its natural setting and involving the solution of a relatively complex problem."[10] "I understand by project a complete unit of experience. . . . Such a unit includes the following phases: situation, problem, purpose, plan, criticism of the plan, execution, judgment of results, appreciation."[11] "A project is a problematic act carried to completion in its natural setting."[12] "The project

8 Cf. Bagley's introduction to Stevenson, "The Project Method of Teaching." Also ibid pp. 4, 5, 9-14, and Kilpatrick, "The Project Method," T. C. R. Sept 1918, pp. 319-335.

9 Kilpatrick, "The Project Method." T. C. R. Sept. 1918, pp. 319-335.

10 Charters, "The Project in Home Economics Teaching," Jour. Home Ec. 10, p. 114.

11 Hosic, quoted by Stevenson, "The Project Method of Teaching," p. 84.

12 Stevenson, ibid, p. 89.

involves the active and motivated participation of the pupil in carrying it out. It does not, therefore, like the topic, lend itself to didactic formal treatment in which the teacher does all the thinking and the pupil passively absorbs."[13]

It is not within the province of this paper to enter into o discussion of hair-splitting differences of opinion concerning the definition of the term "project." It will be observed, from the representative opinions quoted above, that the proponents of the project are in essential agreement upon the main points, that a project involves continued activity on the part of the learner, that this activity is carried on for the sake of solving a real and immediate problem, that the learner carries on the activity for purposes of his own, and that the planning and thinking are done by the learner. This contrasts sharply with much that is typical of customary school activities. The activity of a student during a typical recitation period is sporadic and discontinuous, rather than continuous. Such activities are often carried on without any relation to real and immediate problems. The learner frequently has no special purpose of his own. The teacher often does most of the thinking and all of the planning.

The above summary does not imply that a project always involves the same kind of activity, or that it never involves any of the usual school activities. Most projects are complex and involve doing whatever the nature of the problem at hand demands. This might, in some cases, involve reference to commonly-used school text-books, but would certainly not always include such an activity.

Unfortunately, the real contribution of the project idea has been obscured and clouded by treating the project as an educational method, throwing emphasis upon the change in the teacher's methods and upon the possible gain in motivation rather than upon the change in what the student does and the consequent necessary reorganization of subject-matter and procedure. Evidence of such clouding of the issue is found in the titles of a large number of the books and articles dealing with projects, for example: Stevenson, J. A., *The Project*

13 Woodhull, "The Aims and Methods of Science Teaching." G. S. Q. 1, p. 2.

*Method of Teaching;* Kilpatrick, W. H., *The Project Method,* and Branom, M. E., *The Project Method in Education.* Some of this difficulty seems to be due to unfortunate terminology. At least, the principles and definitions stated do not always agree with such misleading titles. On the other hand, several writers have used the term "project" in just this sense, as an educational method or device to be used in teaching traditional subjects in the curriculum with little change in their organization. This is the sense in which Bonser uses the term in his *Elementary School Curriculum.*[14] Stevenson falls into the same difficulty in many of the illustrations in the last part of his book, *The Project Method of Teaching.*[15]

As soon as a project is used as a mere device for the motivation of school work for which the learner sees no purpose, it ceases to be a project. In this study, in accordance with the essential agreement quoted above, a project will be considered as a continuous activity carried on by an individual for the accomplishment of a *real* purpose and the solution of a *real* problem.

The teacher may use various methods in helping the student carry on his projects. Some of these methods may be peculiar to the project situation, some may not. W. S. Wake, of the Ben Blewett Junior High School in St. Louis, takes the position that a teacher, in working with students who are carrying on projects, may use any one of twelve different methods, or any combination of these methods. "In a pupil's study of the project there will be times when he must be (1) told (lecture method), and times when he must be (2) shown (demonstration or object lesson). There are times when he may (3) work inductively and (4) deductively. He may be (5) ready for the appreciation of nature and the works of man. He learns to do by doing and by letting him do he (6) develops skill (formation of habits). At times he will have to be shown how to (7) study his problem (supervised study). He may not know what to do next, and so there will need to be the (8) assignment of the lesson. The teacher and pupils will want to know what has been done, so there must be (9) the report

14 "Elementary School Curriculum," pp. 96, 114-131, 138-422.
15 "The Project Method of Teaching," pp 192-278.

or recitation. Since repetition is necessary to fix things in one's mind, there will be (10) the drill and (11) the review. And because the pupil is to become a confident, intelligent member of society, the work must be (12) socialized."[16] This analysis seems in part to be strained and artificial, but it gives needed emphasis to the point that the project idea is not primarily a matter of method. On the other hand, some special technique is required to control a group of boys and girls at work upon projects. Just what this technique will be must be determined by experimentation under actual classroom conditions. This is, however, subsidiary to the more fundamental problem of modifying the type of school work carried on by the pupils. The teacher's technique, like the books and materials used, will depend to a large extent upon the nature of the projects being carried on.

The confusion which is found in educational literature, and sometimes in school work, concerning the exact meaning of the term project and its interpretation in practice, is possibly due to several causes:

(1) The difficulty may lie to quite an extent in the use of indefinite terminology. The terms project, project work, problem-project, project-study, project method, project teaching, are all found in current literature. These may be different terms for the same thing. At least, the same fundamental idea may have led to the different interpretations back of the use of the varying terms.

(2) The confusion may be due to a difference between the statement of theory by educational thinkers, who have not themselves tried out the theory under schoolroom conditions, and the applications and examples taken by them from the attempts of teachers to apply the theory under actual teaching conditions. Frequently the illustrative samples show a tendency on the part of teachers to slip back into the traditional type of school work.

(3) The difference between stated theory and illustrative pieces of work which fail to wholly carry out the ideas expressed in such theory, may be due to a lack of an accumulated stock

16 Wake, "The Project in General Science." Sch. Sc. and Math. 19, pp. 643-650.

of suggestive projects for students and teachers. Little has been offered by the theorists to take the place of the traditional activities which are to be supplanted. Naturally, in the absence of something definite with which to work, there is a strong pull back towards the traditional school activities. Students and teachers alike are accustomed to carrying on these activities.

(4) The emphasis upon method in terminology and discussion may be due, in part, to the lack of technique for handling students who are doing a type of work new to the school situation. In the effort to solve this problem of technique the term "method" has been over-emphasized.

(5) The term "project" has become to a certain extent an "educational fad." There is a tendency on the part of many school people to take up such new ideas largely because they are popular. In doing this they tend to slightly modify what they have just been doing and apply the new term. Some, not quite willing to give up the fad just going out, try to keep it and take on the new at the same time. Hyphenated terms like "problem-project" and "project-study" result.

It will be observed from the material presented at the beginning of this section, that the word "project" is common. Further reading of the authorities quoted will serve to convince one that there is a fundamental idea back of all such discussion and all the terms used. This idea is, that school work should be reconstructed upon such a basis that the students themselves, rather than the teacher, shall do most of the work; that students shall work for ends which they can see as immediately worth while, and not for highly artificial ends which even the teacher does not always see and which are to be attained only in the remote future, and that this work be of the sort that is commonly done in the world all about us and not the highly artificial exercises found only in the four walls of the classroom. The name applied to this idea does not matter, except that a uniform concept should be reached for the sake of clear thinking among educational workers. In this study the term "project" is interpreted in accordance with the idea common to the theoretical definitions, regardless of any compromise illustrations which may follow such definitions.

The fundamental idea, which is here called the project idea, is not as new as it may seem from the discussions of the last five years. Essentially the same idea has been presented under different terminology by John Dewey, F. M. McMurray, J. L. Meriam, and others.[17] As a matter of fact, most of the proponents of the project idea are direct or second generation students of Dewey, and it is not difficult to trace the idea back to its source.

In this investigation, in agreement with the summary on page 240 above, the term "project" will be interpreted as follows: (1) A project is an activity, usually complex, which is carried out by a pupil or a group of pupils. (2) In carrying out the activity the student has in mind a purpose which he wishes to accomplish by means of the activity and which he recognizes as attainable, that is, the student has in mind a definite accomplishment. This purpose may originate with the pupil, with the teacher or some other outside source. If, however, the purpose originates with the teacher, it must be adopted and accepted by the student as his own, or the activity ceases to be a project. This does not imply that the student does just as he pleases. The teacher is the final judge as to the value of projects and must establish whatever limits are socially and educationally desirable. (3) The activity must be of the sort in which young people outside of school commonly engage. That is, the activity must be a normal human activity, not an artificial school activity. For boys and girls of school age such activities must be of the sort commonly carried on by individuals of their own age and stage of development, not adult activities which are never engaged in by young people. This means that constructing a wireless receiving set for actual use would be a project. The mere working out of the physical problems of electrical induction in isolation from any normal activities and purposes would not be a project, although the solution of these same problems might be included in the construction of a wireless set. Typical school problems are very rarely, if ever, projects. Projects rarely grow out of traditional school subject-matter. Projects exist and come into being regardless of

17 "How We Think," "School and Society," "Democracy and Education," "Elementary School Standards," and "Child Life and the Curriculum."

such subject-matter and regardless of existing stratifications. Subject-matter is merely a tool for carrying on a variety of projects. The project is not a tool for carrying out school subject-matter.

Two additional qualifications are usually placed upon projects. These are that projects must produce reflective thinking and must include the idea of continuity. Although these two ideas may not be absolutely essential for the making of a project in every case, they are undoubtedly necessary if a project is to be of the greatest value from the educative standpoint. Projects to be most worth while should be problematic in nature, produce reflective thinking, and continue long enough to preclude superficiality. This continuance will insure that projects will be sufficiently large and complex to avoid being expressions of mere whim and superficial interest. It also implies something of the idea of uninterrupted work. The project is to be pursued until the purpose is accomplished or it is definitely determined that it cannot, under the existing circumstances, be accomplished.

In the remainder of this study the term "project" will be applied to situations meeting all of the conditions described above. For illustrations of actual projects which meet these conditions, see the list of projects in this experiment in Chapter II. The term "project work" will be applied to the same situations, but more specifically to the work actually carried on by the pupil. For example, "To collect and identify 25 spring-blooming wild flowers," will be spoken of as a project. The work actually done by the pupil in carrying this out will be spoken of as project work. The term "project teaching" will be applied to a teaching situation in which the pupils are engaged in carrying on projects and doing project work, and in which the teacher is chiefly concerned with guiding, controling and aiding the students engaged in such activities. The term "project method" will not be used except in quotation. The problem of method will be treated separately under the section dealing with the development of the teacher's technique. Other terms, such as "project-problem" and "project-study," will be discarded altogether.

3. SUMMARY OF CLAIMS FOR THE PROJECT IDEA.

The defects in school education for which project work is offered as a remedy, have been enumerated above. In order to get at a more definite basis for the evaluation of such a type of activity, an enumeration of the positive values claimed for project work is necessary. In the pioneer article of W. H. Kilpatrick the following claims for project teaching are made:

1. "The purposeful act does utilize the laws of learning."
   "As set the purpose is the inner urge that carries the boy on in the face of hindrance and difficulty. It brings 'readiness' to pertinent inner resources of knowledge and thought."
   "Satisfaction in detail and in respect of the whole by the automatic working of the second law of learning (Effect) fixes the several bonds. . . ."
2. "The unified set of wholeheartedness will render available all the pertinent connected inner resources. A wealth of marginal responses will be ready to come forward at every opportunity . . . each step will be connected in many ways with other experiences."
3. "Desirable concomitants are more likely with the hearty purposeful act."
   ". . . Attention is more easily led to helpful generalizations of method and to such ideals as exactness and fairness."[18]

J. A. Stevenson, in *The Project Method of Teaching,* states the following advantages for project work:

1. "The natural setting of the project makes provision for a strong motive."
2. "The project is able to create interest of a deep-seated sort, because the interest comes from associated connections from many sources."
3. "The potentiality of interest in projects is great because of their wide and varied connections."
4. "They will be worked at with a maximum effort because they hold great significance for the learner."
5. "The project gives the ideal organization of subject-matter to arouse an aim and direct thinking."
6. "The project offers a convenient unit to carry forward information simultaneously with its function."
7. "The project as defined makes provision for the necessary requisites for thinking as outlined by Dewey."
8. "It develops the attitude of scientific research that should be fostered in our secondary schools. . . . Indeed, projects furnish the natural means for developing scientific attitude."
9. "The project furnishes the opportunity for placing pupils in situations in which it is absolutely necessary that they think in order to solve the difficulty."
10. "The project offers a means of providing training in action."

18 Kilpatrick, "The Project Method." T. C. R. Sept. 1918, pp. 325, 324-325, 326, 327.

11. "The project method takes care of the technique of carrying out a complete act."[19]

Suzallo, in the introduction to Stockton's *Project Work in Education*,[20] states the claims for project work as follows:

1. "The study of vitally related facts in isolation from each other is overcome by studying truths as required and related by the need to solve problems connected with the execution of desirable projects."
2. "Personal initiative in the finding of needed facts and discriminating judgment in determining the relative worth of facts found are two powers which are stimulated and developed. . . ."
3. "Working and living attitudes are provoked and corrected in connection with actual realities and working aspirations. . . ."
4. "The need of high standard skills in doing is readily appreciated and practice work heartily accepted by students that see that faint skill, or no skill, leads to obvious failure and that ample and refined technique in execution leads to marked success."

The claims for project teaching just quoted are representative of such claims and cover most of the values stated by the advocates of this type of activity. Briefly stated, it is claimed that projects will secure greater interest in school work, a maximum effort on the part of pupils, better thinking, a better grasp of subject-matter, training in finding and judging facts, the development of high standard skills and the development of desirable attitudes and ideals of work.

The problem now becomes one of determining the extent to which these claims are realized in actual practice. To do this will require a number of experimenters working through a considerable period of time. This study is necessarily limited in scope to the realm of experimentation possible in a single investigation. It is, therefore, necessary to scan the claims for project work in the field of this particular study. What, then, are the values claimed for the project in the field of general science?

Stevenson, in an article on *The Project in Science Teaching*,[21] makes the following statement concerning the value of project teaching in science: "The project method rightly carried out develops great interest, gives training in carrying acts to completion, provides adequate opportunity for directing thinking and reasoning." Woodhull presents perhaps the best series of

19 "The Project Method of Teaching," pp. 116-125, 135-136
20 "Project Work in Education," pp. VII-VIII.
21 Sch. Sc. and Math. 19, pp. 50-63.

arguments for project teaching in general science. He says, in part:

"The real way to learn fundamental principles is to attack those principles of which life is full for each individual, not through the preparatory fallacy called scientific method, but by a 'forked road situation.' . . . No more diligent or effective application of the inductive method in education has ever been witnessed than that proposed. . . . The knowledge which is the boy's quest in project study is knowledge of which he sees the need. Being needed year by year, it will, year by year, be recalled. Used again and again, added to, modified and exactly applied, it will tend to be distinctly remembered. The project method of education, more, it is believed than all others, takes into account the aptitudes, requirements and accomplishments of individual pupils as these are revealed from hour to hour. . . . The method is precisely that of the masters of research, who are, after all, *Masters of General Science*."[22]

D. L. Lott makes a strong plea for project teaching in science as a means for training students in scientific method.[23] C. R. Mann, in an article on *Project Teaching*,[24] advocates project teaching in science on the ground that a much better scientific technique is developed through projects, because the development of such technique follows the feeling of need by the student. David Snedden states the following values for projects and illustrates their application in the field of general science: (1) unity in the undertaking, (2) interest through the practical outcome expected, (3) ability of the learner to render decisions as to the worth of the product because of objective standards of achievement, (4) the necessary application of facts gained through previous experience, (5) the acquiring of new knowledge and skills.[25] G. R. Twiss quotes *Some Fundamental Principles* formulated by the Committee on General Science of the N. E. A. Principle number nine of this committee reads as follows: "The project method of teaching, when well done, leaves the pupil with a well-organized mass of useful information plus a love of the scientific spirit which will lead him to continue to acquire more. This entire discussion arises from the fact that the topical method has failed to do just this."[26]

22 Woodhull, "Science Teaching by Projects." Sch. Sc. and Math. 15, pp. 225-232.

23 "The Conscious Development of Scientific Ideals in Secondary Science Education." Sch Sc. and Math. 17, pp. 417-426.

24 G. S. Q. 1, pp. 13-14.

25 "The Project as a Teaching Unit." Sch. and Soc. 4, pp. 419-423.

26 "The Principles of Science Teaching," pp. 421, 422.

From these quotations it seems that there is close agreement between the advocates of project work in general and the advocates of such work in the more limited field of general science. The chief difference lies in the more specific claims of the general science group that students who carry out science projects get more scientific information, retain such information better, and secure better training in scientific method and attitude than students who have been engaged in traditional school activities in general science. To what extent can these claims and the broader claims of the other exponents of project work be justified?

### 4. COMMONLY ACCEPTED AIMS OF GENERAL SCIENCE TEACHING AND THEIR RELATION TO PROJECT TEACHING.

In the preceding section a summary of the claims for the values of project teaching was presented. This summary was secured from the statements of representative proponents of the project idea. To what extent can the validity of these claims be determined? From the point of view of the educational worker, since a project is a type of student activity, it is to be judged by the results,—by its effects upon the student. The results in turn are to be judged by comparison with the aims which society and its agency, the school, set out to accomplish. In the somewhat narrow field of general science the results accruing to the students engaging in a particular activity may be judged in terms of what the school expects to accomplish with students in that field. The theoretical and ideal picture of the teaching process may be presented in the following order: (1) objectives to be secured, (2) activities of pupils through which they may attain the expected results, (3) activities of the teacher in guiding and aiding student activities, (4) materials used in carrying out these activities and material conditions influencing them, (5) checking to see if the objectives have been reached. The value of project work as a type of pupil activity in general science may be judged by the extent to which such activity accomplishes commonly accepted aims for general science teaching.

Undoubtedly the spread of the project idea and the introduction of project work into school practice carry with them

important modifications in the objectives.[27] The widespread criticism of the products of our schools indicates that this modification is needed. Indeed, changed objectives growing out of such criticism should be superior to those now current, which have produced the results criticized. To prove that they are superior by controlled scientific experiment seems, under present conditions, impossible, chiefly because there seems to exist no general agreement upon just what such modifications should be. There are many hints and suggestions in current literature. There is considerable agitation, but not much in the way of concrete proposals. The list of specific and detailed objectives presented in this study is the first attempt at such a piece of work in the field of general science.[28]

In view of the conditions outlined, the best evaluation of such a type of activity as project work seems to lie in determining to what extent students engaging in such activity attain the commonly accepted aims for general science teaching. If these current aims can be attained incidentally while students at the same time are engaging in a type of activity which has claimed for it decided advantages over present types of activity, the new type can be justified. Mr. P. G. Buckles, the teacher of one of the experimental groups, said in effect: "My year with these people has been well spent if they have learned no general science subject-matter, because of their great growth in socialization, in ability to work well together, and to do both independent and group work." Kilpatrick says that project work is valuable because it utilizes the laws of learning,[29] implying that other types of school work do not. Woodhull[30] and others claim that project work produces within the student the ability to attack and solve his own problems. If a student, by carrying on a series of projects, can incidentally reach the current objectives for general science and possibly reach the results suggested above and secure the claims presented in section 2, project work is worth continuing. If, on the other hand, stu-

27 See objectives accompanying the list of projects used in this experiment in Chapter II.

28 See Chapter II.

29 Kilpatrick, "The Project Method" T. C. R. Sept. 1918, pp. 325 ff.

30 Woodhull, "Science Teaching by Projects." Sch. Sc. and Math. 15, pp. 225-232.

dents do not reach commonly accepted aims for general science, it is doubtful if a case for project teaching in general science can be made at present. It is proposed, therefore, to attempt to determine whether students doing project work do as well as students in traditional school activities in reaching the commonly accepted objectives in general science.

What, then, are these commonly accepted aims for general science teaching? For purposes of this investigation a review was made of all the material in *School Science and Mathematics* from January 1, 1910, to December 1, 1921, and in the *General Science Quarterly* from the beginning of its publication in November, 1916, to March, 1922. To this has been added material from the books on science teaching, scattered references to other periodical material found in general science bibliographies and the statements of aims found in the prefaces to all available general science text-books. The aims proposed in all of this material will be found in tabular form below. (Table I.) In this table the name of the authority is given in the first column. In the second is given the position of the individual stating the aims. In the third are numbers which refer to the published sources of the aims given in the bibliography attached to the table. The aims found are designated by the letters A, B, C. etc., at the top of the table. The key to these aims follows the table. A check mark in one of the vertical columns after an individual's name indicates that that individual has given the aim for general science designated by the letter found at the top of the column. Aims having a frequency of less than 10 out of the total of 44 cases were omitted from the final table in order to save space. The aims found were fitted into the categories used on the basis of opinion and individual judgment. Wherever an aim did not seem to fit into any of the categories used a new class was made and carried to the end of the survey. Categories with low frequencies were omitted from the tabulation shown, in order to save space.

## Table I.

### AIMS OF GENERAL SCIENCE TEACHING.

| Authority | Position | Reference | Aims | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G |
| Adams, W. A., | Prof. Chemistry, Ill. Normal Univ. | 1 | | | | X | | X | X |
| Austin, R. O., | Teacher H. S. Commerce, N. Y. | 2 | X | X | X | | X | | X |
| Barber, F. D., | Prof. Physics, Ill. Normal Univ. | 1 | | | | X | | X | X |
| Bedford, E. A., | Dept. Gen. Science, De Witt Clinton H. S. | 3 | | | X | X | | | |
| Briggs, T. H., | Assoc. Prof. Educa., Teachers College | 4 | X | | | X | X | | |
| Brownell, H., | Prof. Sc. in Sec. School Univ. Nebraska | 5 | | | X | | X | X | |
| Caldwell, O. W., | Director, Lincoln School, N. Y. | 6, 7 | X | X | X | X | | | |
| Carpenter, H. A., | West H. S., Rochester, N. Y. | 8 | X | | X | X | X | | |
| Clark, Bertha, | Head Sc. Dept., Wm. Penn H. S., Philadelphia | 9, 10 | | X | | X | | | |
| Collister, M. C., | Utica Free Acad., N. Y. | 11 | X | | | X | | | |
| Downing, E. R., | Prof. Tch Sc., Univ. Chicago | 12, 13 | | X | X | | | | |
| Eikenberry, W. L., | Prof. Educ., Univ. Kans. | 14, 15, 16 | X | | | X | | | |
| Fall, D., | Prof. Chemistry, Albion College | 17 | | X | | | | | |
| Heald, F. E., | Agent Agric Tch. Training in U. S. | 18 | X | X | | X | X | X | |
| Hodgdon, D. R., | Director Newark Sch. Tech. | 19 | X | | X | X | | | X |
| Hofe, G. D. von, | Teachers College, N. Y. | 20 | | | | X | X | | |
| Hunter, G. W., | Prof. Biology, Knox College | 21, 22 | | | | X | | X | |
| Huntington, E. D., | Normal Sch., Kalamazoo, Mich. | 23 | X | | | X | | | |
| Inglis, A., | Asst. Prof. Educ., Harvard | 24 | | | X | | | X | |
| Jewett, E. G., | Author Int. to Study of Science | 25 | | X | | X | | X | |
| Johnson, A. J., Jr., | Englewood, N. J., H. S. | 26 | X | | X | | | | |
| Kelley, H. C., | H. S. Commerce, Springfield, Mass. | 27 | | | X | X | X | X | X |
| Kendall, C. N., | Commissioner Educ., N. J. | 19 | | | X | X | | | X |
| Lake, C. H., | Author Gen. Sc. Text | 28 | X | X | X | | | | |
| Lunt, J. R., | Teacher, Eng. H. S. Boston | 29 | | | | X | | | X |
| Masters, F. G., | Sc. Teacher, Pittsburg, Pa. | 30 | X | | X | | | | |
| Orr, Wm., | Dep. Commissioner Educ. Mass. | 31 | | | | X | X | | X |
| Pease, Clara A., | H. S. Hartford, Conn. | 32 | X | | X | | | | |
| Pricer, J. L., | Prof. Biology, Ill. Normal Univ. | 1 | | | | X | | X | |
| Rowell, P. E., | Teacher, Gardena, Calif., H. S. | 33 | | | | X | | | X |
| Smith, E. L., | Instructor Boston Normal School | 34 | | X | | X | | | |
| Snedden, D., | Prof. Educ., Teachers College | 35 | | X | X | | | | |
| Snyder, W. H., | Prin. Hollywood H. S., Los Angeles | 36 | X | X | X | | | | X |
| Thalman, J. L., | Prin. H. S., Newcastle, Pa. | 37 | X | X | X | | | X | |
| Trafton, G. H., | Instructor in Sc., Mankato Normal | 38 | | | | X | | | |
| Twiss, G. R., | Prof. Educ., Ohio State Univ. | 39 | X | X | X | X | X | X | |
| Van Buskirk, E. F., | Asst. Educ. Direc. U. S. Public Health | 34, 40 | X | X | X | X | X | | |
| Washburne, C. W., | Supt. Schools, Winnetka, Illinois. | 41 | | | X | X | | | |

| Authority | Position | Reference | Aims A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| Waterhouse, R. H., | Prin. Jr. H. S., Amherst, Mass. | 42 | | | | X | | X | |
| Weckel, A. L., | Biology Dept. H. S., Oak Park, Ill. | 37 | X | X | X | | | X | |
| Whitman, W. G., | Editor Gen. Sc. Quarterly | 21, 43 | | | | X | | X | X |
| Woodhull, J. F., | Prof. Physical Sc., Teachers College | 44 | | X | X | | | | |
| Worun, A. A., | Soo H. S., Saut Ste. Marie, Mich. | 45 | X | | X | | | | |
| Totals, | | | 19 | 16 | 23 | 28 | 10 | 14 | 11 |

## KEY TO GENERAL SCIENCE AIMS IN TABLE I AND SUMMARY.

| Key Letter | Aim | Number Standing for Aim |
|---|---|---|
| A. | Preparation for later science courses | 19 |
| B. | Training in scientific method | 16 |
| C. | Information about nature and science | 23 |
| D. | Better understanding and control of environment | 28 |
| E. | Culture | 10 |
| F. | Development of power of interpretation and appreciation | 14 |
| G. | Development of interest in science | 11 |

## REFERENCES USED IN TABLE I.


1. *First Course in General Science.* Preface.
2. *Need and Scope of First Year General Science Course.* Sch. Sc. and Math. 11, p. 217-224.
3. *General Science.* Preface.
4. *General Science in Secondary Schools.* T. C. R., Jan. 1916, pp. 19-30.
5. *Laboratory Lessons in General Science.* Preface.
6. *Report on a Four Year's High School Science Course.* Sch. Sc. and Math. 14, pp. 166-188.
7. *Elements of General Science.* (Revised Ed.) Preface.
8. *General Science.* Sch. Sc. and Math. 17, pp. 214-222.
9. *Humanism and Efficiency.* Educ. Rev. May 1914, p. 489.
10. *Aims and Purposes of General Science.* G. S. Q. Nov. 1919, pp. 291-295.
11. *Pupil's Interest as a Foundation in Science Teaching.* G. S. Q. May 1921, pp. 222-225.
12. *Supervised Study and the Science Laboratory.* Sch. Rev. 23, p. 733.
13. *Aims of Science Teaching and Changing Enrollment.* G. S. Q. Nov. 1917, pp. 253.
14. *General Science Course in the University High School.* Sch. Rev. 20, pp. 217-227.
15. *Elements of General Science.* Preface.
16. *Teaching of General Science.* Ch. V.
17. *Science for Beginners.* Preface.
18. *General Science in the Agricultural High School.* G. S. Q. March 1919, pp. 160-165.
19. *Elementary General Science.* Introduction.
20. *General Science is Project Science.* Sch. Sc. and Math. 15, pp. 751-757.

21. *Civic Science in the Home*, p. 7.
22. *Relation of General Science to Biological Science in the Secondary Schools.* G. S. Q. March 1920, pp. 381-389.
23. *An Experiment in Organizing a Course in General Science.* Sch. Sc. and Math. 12, pp. 667-672.
24. *Principles of Secondary Education*, p. 528.
25. *Introduction to the Study of Science.* Preface.
26. *Selection and Arrangement of Material in a General Science Course.* G. S. Q. Jan. 1917, p. 83.
27. *The Springfield Plan.* G. S. Q. May 1917, pp. 191-200.
28. *General Science.* Preface.
29. *Methods of Vitalizing the Teaching of General Science.* G. G. Q. May 1921, p. 200.
30. *Elementary Science, Its Value and Place in the Secondary School Curriculum.* Sch. Sc. and Math. 11, pp. 718-723.
31. *General Science Bulletin.* G. S. Q. Nov. 1916, pp. 37-46.
32. *A First Year Course in General Science.* Preface.
33. *General Science.* Sch. Sc. and Math. 10, pp. 703-706.
34. *The Science of Everyday Life*, p. 1.
35. *Principles of Aim, Origin and Method in General Science Teaching.* Sch. and Soc. 1, p. 438.
36. *Everyday Science.* Preface.
37. *A Year in Science.* Preface.
38. *Teaching Science in the Elementary School*, pp. 10-16.
39. *The Principles of Science Teaching*, pp. 82 ff.
40. *Aspect of Biology in General Science and Aims to be Attained.* Sch. Sc. and Math. 21, pp. 307-315.
41. *Common Science.* Preface.
42. *General Science in Amherst Junior High School.* G. S. Q. Jan. 1918, p. 318.
43. *The Place and Purpose of General Science in Education.* G. S. Q. Nov. 1917, pp. 284-293.
44. *The Teaching of Science.* p. 1 ff., Ch. V and XII.
45. *Review of Current Literature.* Sch. Rev. 25, p. 455.

From this table it will be seen that the aims showing the greatest frequency, more than 50%, are "better understanding and control of environment" and "information about nature and science." Other aims frequently expressed are "training in scientific method," "preparation for later science studies," and "the development of the power of appreciation and interpretation." These latter, however, do not occur with sufficient frequency to demonstrate any great degree of unanimity concerning them among general science advocates.

Four other studies of the aims of general science teaching practically substantiate the data given here. C. M. Howe[31] sent a questionnaire to a large number of general science teachers. In this questionnaire he suggested the following nine aims:

31 "Can and Should General Science be Standardized." Sch. Sc. and Math. 19, pp. 248-255.

1. "A fund of valuable information about nature and science."
2. "Greatest possible understanding, appreciation and control of everyday environment."
3. "Preparation and foundation for later study of special sciences."
4. "Appreciation of the applications of science in modern industrial and social problems."
5. "Training in the use of scientific method."
6. "Interest and motivation in school work."
7. "A vocational survey of the sciences."
8. "Appreciation of the unity and beauty of science and its master minds."
9. "Training in cold, scientific thinking."

From 80 replies there were 53 first choices for the understanding, appreciation and control of everyday environment; 12 for a fund of valuable information about nature and science; 8 for training in scientific method, and 6 for preparation for later science. The remaining first choices were scattered.

A. A. Worun,[32] in his survey of general science in Michigan, included in his questionnaire a schedule on aims. From 101 replies he secured the following results:

| | |
|---|---|
| Foundation for future science courses | 47 |
| To explain the pupil's environment | 31 |
| Science for pupils who drop out of school early or who do not elect special science | 19 |
| Unclassified | 4 |
| | 101 |

W. F. Roecker,[33] in a similar study in Wisconsin, secured the following results:

| | |
|---|---|
| General information | 33 |
| Preparation for later science | 31 |
| Miscellaneous | 27 |

C. F. Miller,[34] using Howe's questionnaire in a survey in Illinois, secured the following results from 81 replies:

| | |
|---|---|
| Greatest possible understanding, appreciation and control of environment | 38 |
| A fund of valuable information; nature and science | 18 |
| Preparation for later science studies | 11 |

32 "General Science in Michigan." G. S. Q 2, pp. 267-284.
33 "An Elementary Course in General Science." Sch. Sc. and Math. 14, pp. 755-758.
34 "Survey of the General Science Situation in Illinois." Sch. Sc. and Math. 19, pp. 398-406.

Appreciation of the applications of science ..... 5
Miscellaneous ..... 9

Summarized, the above four studies can be presented somewhat roughly in the following table (Table II):

Table II.

A SUMMARY OF STUDIES OF AIMS OF GENERAL SCIENCE.

| Aim | Frequency H | W | R | M | Total |
|---|---|---|---|---|---|
| Understanding, appreciation and control of environment ..... | 53 | 31 | 0 | 38 | 122 |
| A fund of valuable information..... | 12 | 19 | *33 | 18 | 82 |
| Preparation for later sciences..... | 6 | 47 | 31 | 11 | 95 |
| Miscellaneous ..... | .. | .. | .. | .. | 54 |

H—Howe's study. W—Worun's study. R—Roecker's study. M—Miller's study.

* Placed here, as "science for people who drop out of school" is interpreted as scientific information.

This table is not altogether accurate, because of inaccuracies in the original data. Howe had only 80 cases, but presented more than 80 first choices because of some duplication in replies. Roecker received 50 replies to his questionnaire, but presents 91 choices in his tabulation. This serves chiefly to raise the number in the miscellaneous group, since 27 of Roecker's replies are classified as miscellaneous. Disregarding these discrepancies, this summary of the four studies does show the trend of thought of practical school workers concerning the aims of general science teaching.

From the two sets of evidence presented above it seems safe to assume that the chief current aims of general science teaching, both from the point of view of educational writers and the teachers carrying on the work, are: (1) securing an understanding and control of environment; (2) the acquisition of a fund of information concerning nature and science, and (3) preparation for later science courses. Since training in scientific method does not occur more frequently as an aim in either summary, it seems safe to assume that what is meant by preparation for later science courses is essentially the acquisition of a fund of scientific information. The crucial point in this investigation, therefore, becomes that of determining whether students doing project work secure as great an understanding and control of every-day environment and as much natural science information as students engaging in traditional school activities.

*(To be continued.)*

# A Science Laboratory and Classroom for Secondary Schools*

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University High School, Oakland, Calif.

The history of science teaching can be read most clearly in two sets of documents: textbooks and building plans; for these are at once the resultant and determiners of teaching practices.

The first laboratory for teaching of which we have record was that of Vigani,[1] professor of chemistry, 1703-1712. This was fitted up in 1707, an old "lumber-hole" being made into an "Elegant Chymical Laboratory." The writer of a contemporary pamphlet says: "I am not one of those who glory in running down Chymical observations and experiments; but yet with regard to this so famous Laboratory of Ours, I have talked with those that have gone the courses, and they all seem of the opinion that, as those matters are managed, the learned World is not like to reap any mighty profit or advantage from anything that is there taught."[2]

From this unfriendly beginning little progress was made until the great revival of science teaching in the latter part of the nineteenth century. Dr. Shipley records that when he began to study botany in 1879, "The only attempt at practical work was to hand around flowers in the lecture room, which we sometimes dissected, but I am afraid more frequently threw at the lecturer." He gives to Huxley in England and Martin in the United States the credit for inaugurating the modern system of laboratory instruction in biology.

The development of laboratory instruction has gone hand-in-hand with an increasing appreciation of the value of first-hand knowledge. "To look with the eyes is to confound the wisdom of the ages." The usefulness of the laboratory for teaching

* Reprinted from "School Board Journal," by courtesy of the Bruce Publishing Company.

1 See "Laboratories: Their Planning and Fitting," by Munby. Introduction by A. E. Shipley. D. Van Nostrand, 1921.

2 Quoted from Munby, p. XII.

purposes has been generally recognized since the early eighties. First, in colleges and universities, and some ten or fifteen years later in the secondary schools, fairly adequate provision for "practical work" was made.

### LABORATORIES TOO EXPENSIVE.

This provision has involved a very considerable increase in the cost of school plants. The question has been raised as to whether the educational usefulness of the laboratories has been great enough to warrant the large expenditures made on them. In a world so extensively "complicated by scientists" no price is too great for a nation to pay for the dissemination of science, especially among those students who are to be the leaders of its affairs; but the laboratory, as we have built it and used it in secondary schools, has too often discouraged and disheartened our students. One consequence of this state of affairs has been renewed emphasis on demonstration work to replace much that is now done as individual work, particularly by younger students. This concession on the part of science teachers is readily seized upon by administrators, who see a welcome release from the burdensome expense of laboratory construction and maintenance. While there is no question as to the worth of demonstrations there are fundamental values in laboratory work, carried out individually or in small groups, which can never be obtained from the most skilful and illuminating of demonstrations. To obtain these values, we must make certain modifications in science classroom procedure, and these in turn will demand appropriate modifications in science classroom construction.

A laboratory in a secondary school exists to afford students first-hand contact with the tools and materials of science. It is not designed primarily for experimentation as is the research laboratory. The young student cannot, in the nature of things, discover all the generalizations of science through putting his own questions to nature. A great deal of wasted time and stupid pretense has resulted from our failure to admit this at the outset. First-hand contact with tools and materials may do three things for our students: (1) give them a richer background of experience out of which to build those general notions which are fundamental to science; (2) provide facilities for

acquiring desirable specialized skills; and (3) open up a delightful world of opportunities for what Snedden has called "learning on the high-grade play level."

### INTEREST ESSENTIAL.

To fulfill any of these possibilities, the student must approach his laboratory experiences with a definite understanding of what he is about, and a zest for the undertaking which springs out of his appreciation of its value. "Laboratory experiments must concern a problem or a question which the pupil seeks to answer because he is interested in doing so."[3] This attitude can grow only out of class discussions carefully planned to develop it. This involves, on the side of teaching technique, a new emphasis on class discussion and development of laboratory exercises and problems; and on the side of school-planning, provision for greater flexibility in the use of the laboratory facilities, and for a closer physical relationship between the classroom and the room for practical work.

This flexibility and closer relationship may be obtained most readily by the use of a room which is neither "lecture theater" nor laboratory, but a teaching workshop, providing physical facilities for all the essential means of teaching science which are at the disposal of the modern teacher, at least as far as these can be brought within the walls of a schoolroom. For want of a better name, we have called this a science classroom.

### SCIENCE ROOMS IN OAKLAND.

The science classrooms described later were planned for the new plant of the University High School, Oakland, California. This city is engaged in an extensive school building program, emphasizing especially adequate housing for its junior high schools. Under the leadership of the Superintendent of Schools, Mr. Fred M. Hunter, the policy adopted by the Construction Department has been one of most cordial co-operation with the administrative and teaching forces in working out building plans which should provide good teaching workshops at reasonable cost, in buildings of creditable design and sound construction. The supervising architect, Mr. C. W. Dickey, has placed at the disposal of the writers, not only his large and valuable collections of school laboratory plans and notes, but also the

3 Bulletin No. 26, 1920, U. S. Bureau of Education.

services of one of his assistants, Mr. D. V. Deuel, whose native ingenuity and long experience in planning and equipping commercial and research laboratories have furnished by far the most valuable contribution this paper has to offer. The accompanying plates are evidence of his skilled draughtsmanship. The writers feel that the year's work under these conditions has afforded a liberal education, as well as great pleasure and satisfaction, which they are glad to acknowledge.

Because of very definite financial limitations, the type of construction adopted imposed certain restrictions, to which these plans conform. Recognizing that others may face similar financial problems, it has seemed worth while to describe the plans finally chosen as offering a practical solution of our difficulties.

The school plant is intended to house a six-year junior-senior high school, with 600 pupils in the lower division and 600 in the upper. General science will be offered throughout the junior high school, and the more specialized sciences in the senior high school. For purposes of economy and convenience in administration, the rooms for the whole department have been grouped as a unit. This aids in securing closer co-ordination between the various courses and co-operation among the teachers of them.

## WHAT THE PLANT INCLUDES.

It was decided that our first consideration should be to obtain a complete plant so arranged that each room would be available for as many types of work as possible, and that no essential phase of secondary science should be neglected.

Aside from the classrooms certain conveniences are provided for the use of the department as a whole. These are:

1. Outdoor laboratory, or science garden.
2. Science shops.
3. Science storerooms.
4. Visual education and lecture room.
5. Dark room.
6. Department office and library.

The provision of these special features makes it possible to relieve the science classroom of many details which are ordinarily necessary for good workmanship. This plan saves room and expense, and it is hoped will prove more efficient than the

older scheme of outfitting completely each laboratory-classroom unit. These special rooms will be more fully described later.

A science classroom was designed which, somewhat modified, serves equally well for general science, chemistry, physics, and biology. The room is planned to take care of 24 students,[4] this much leeway being necessary in order to maintain a class of twenty throughout the year. The dimensions (24′x38′) are satisfactory as to length but not as to width. This width was made necessary by the type of building construction adopted. The plans have been adjusted to it by a series of compromises which it is hoped, will not seriously impair the working efficiency of the room, and which may secure some of the advantages of compactness and step-saving efficiency of the modern apartment-house kitchenette.

## TEACHING DEVICES.

Since the class discussion holds a place of such prime importance among teaching means and devices, adequate provision for it has been our first consideration. A sliding blackboard and projection screen, a demonstration table, and a set of tablet-arm chairs are arranged at one end of the room. (See Plate 1.) The table has been kept as small as possible, but is fully equipped with sink, gas, hot and cold water, and both DC and AC current. Where possible, a small detachable fume-hood has been included in this equipment. The side of the table facing the class carries large shallow drawers for holding maps, charts and diagrams, in dust-free, readily accessible form. The opposite side of the table is fitted to accommodate necessary materials. (See Plate 2, Figs. 1 and 2.) In adjacent wall space a cabinet contains everything that would ordinarily be needed in demonstration work.

The remainder of the room (about 24′x22′) is devoted to the work-tables and their accompanying storage cabinets. Three tables (13′x3′ 4″) are placed across the room, with apparatus case and students' service case along one wall, and window-shelf and work-bench under the windows along the opposite wall.

4 By using the demonstration table to accommodate six students, a class of thirty can be taken care of. This is not recommended except in emergencies. Where a class of thirty must be carried the room should be sufficiently enlarged to provide an additional laboratory table accommodating eight students.

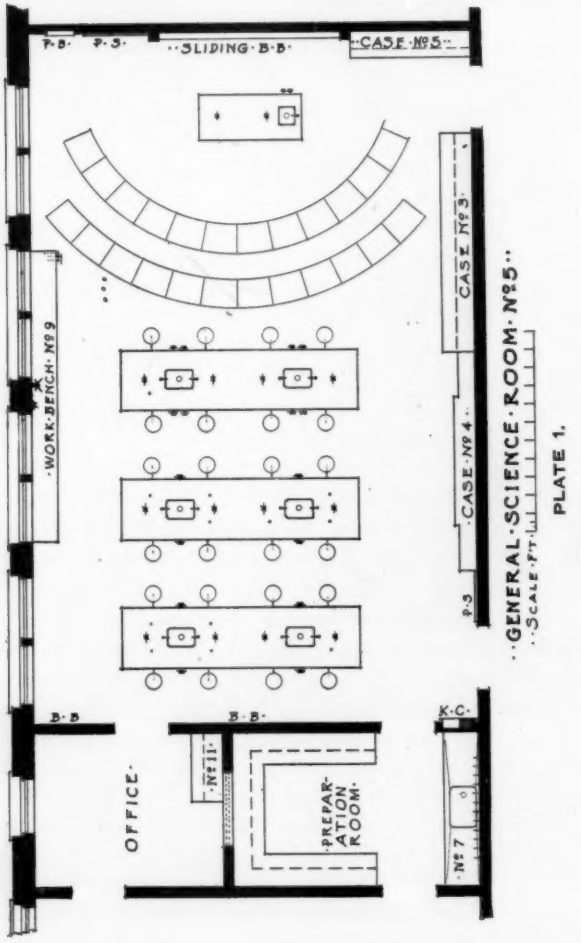
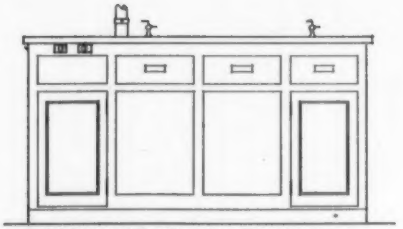
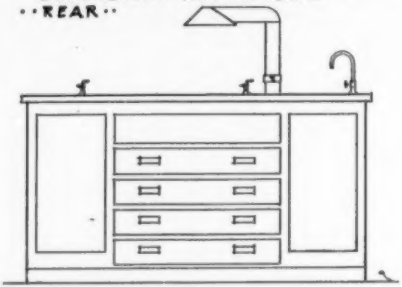

P.B.
P.S.
SLIDING B.B.
CASE No 5
CASE No 3
CASE No 4
WORK BENCH No 9
B.B
B.B
OFFICE
No 11
PREPARATION ROOM
K.C.
No 7
P.S
GENERAL SCIENCE ROOM No 5
SCALE FT

PLATE 1.




Figs. 1 and 2.

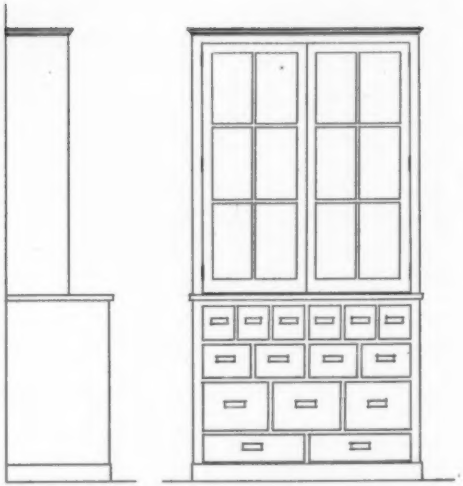



PLATE 2.

Figs. 3 and 4.

Office and preparation room open from the rear of the room.

If it were possible to set the tables parallel to the long axis of the room instead of at right angles to it, certain advantages would be obtained; the narrowness of the room, however, makes that impractical.

Each section of the apparatus case (Plate 3), which is placed adjacent to the laboratory tables and at right angles to them, is designed to serve a group of eight pupils, furnishing the group with one section of four drawers and four shelves. This leaves two sections of drawers and one section of shelving for extra storage space. Experimental work may be carried on by individuals, by small or by large groups; but the unit of eight pupils assumes entire responsibility for the care of such community property as sinks, hoods, reagent bottles, iron supports, and the materials stored in its section of the apparatus case.

### STUDENTS' AND MICROSCOPE CASES.

Adjacent to the apparatus case is a student service case, consisting of students' lockers, a notebook case, and a microscope case. This is placed near the door and provides a pigeonhole for each student's notebook, and a larger compartment, his for the period only, in which he stores his books and other impedimenta. This scheme saves table space and protects the covers of the school textbooks. The microscope case (Plate 4), provided in all except chemistry and physics rooms, has dust-free compartments, protected by sliding glass sashes. It is felt that these cases will provide a fairly adequate set of individual and group working materials, and should materially diminish aisle crowding and general student traffic about the room. The whole aim of this unit is to suggest to the student that a laboratory is indeed a workshop, affording little opportunity for anything but consistent application to the business in hand.

In attempting to design laboratory furniture to fit the dimensions of the rooms provided, we found it not advisable to install work-tables accommodating less than eight pupils when the room is to be under 28 feet in width. The ideal laboratory should be at least 30 feet in width, provided with tables accommodating groups of four pupils each, with adequate aisle space between the various units. Owing to the limitations of the

type of building construction adopted, it was not possible to furnish class-rooms more than 24 feet in width, with the result that we were forced to use an eight-pupil table. Placing four pupils on a side, each one has a working space of 39″x20″, with an individual gas outlet; and a water faucet, a DC outlet and a fume hood in common with his neighbor. Each student has an individual drawer, except in the general science classes, where two students are assigned to one drawer. A swinging stool, 22″ from the floor, is employed to reduce the aisle-crowding and disorder.

### Table Equipment.

The table top, of non-warping maple construction, is provided with two sinks of convenient dimensions for the collection of gases, and sufficiently deep to prevent undue spattering of water. The chemistry tables (See Plate 5) are provided with reagent shelves of plate glass sufficiently low to be convenient for the pupils and to give the instructor an unobstructed view of every point in the room. Small threaded sockets are placed in suitable positions to receive iron supports, thus obviating the necessity of storing clumsy iron ring-stands. The sockets, of nickel-plated brass, are non-corrosive and are deep enough to render the supports very rigid when in position. When not in use, the supports may be stored in small wooden troughs at the ends of the tables.

All work-tables, excepting those in the chemistry rooms, are 32 inches in height, with stools 22 inches from the floor. The chemistry tables are 36 inches high, with stools 26 inches from the floor. The lower table is advised for rooms in which any microscopic work is to be done. The tendency in modern laboratories seems to be distinctly away from the very high tables used a decade ago. There is special need to consider height carefully in rooms designed for junior high school students.

In the chemistry rooms one vent hood is provided for each two pupils. It was felt that the ordinary provision of one or two fume-hoods along the side wall of a laboratory was so inadequate as to be practically useless. Experience and observation show that such fume-hoods are usually cluttered with the odds and ends of typical laboratory "glory-holes," indicating their very infrequent use. There is no doubt that the fumes so constantly in evidence in laboratories are far from

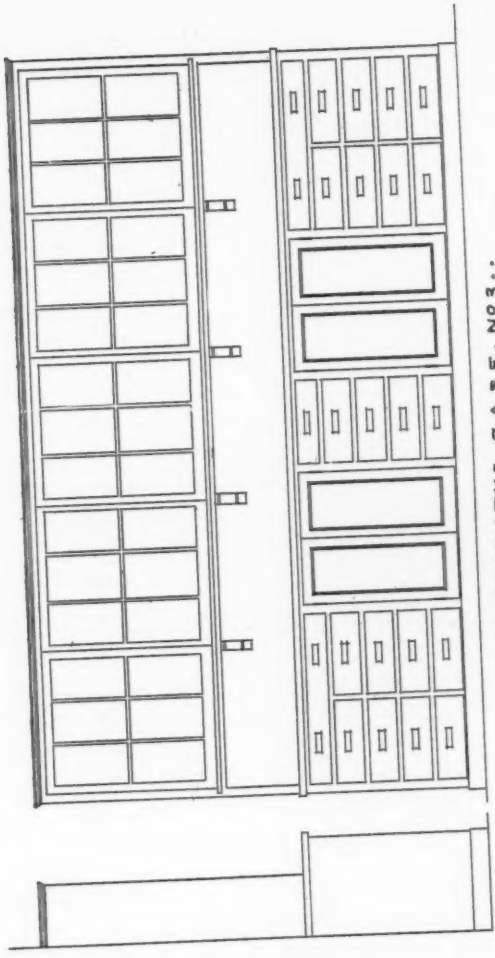



PLATE 3.

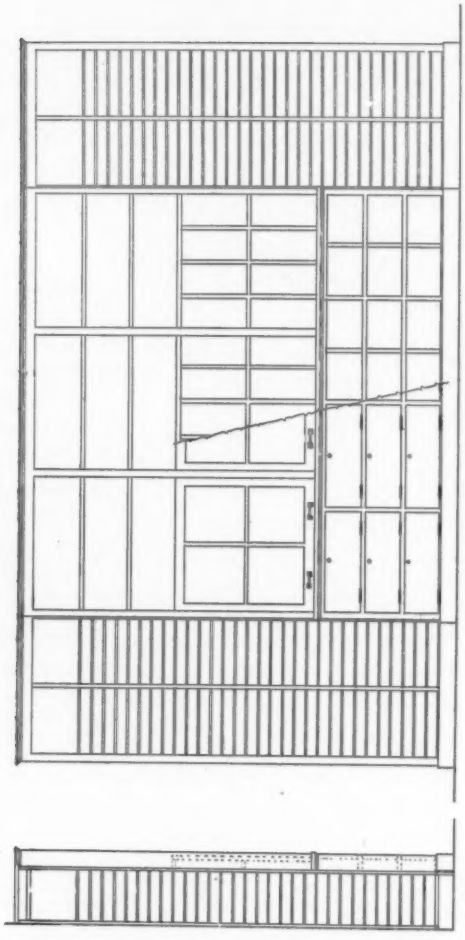



PLATE 4—Microscope Case.

beneficial to the human respiratory tract. This is particularly serious for the teacher, who must spend his whole working day in such an atmosphere. It was hoped that by providing plenty of well-ventilated hoods, conveniently placed, the student might be induced to use them, and so spare his own lungs and those of others. The fume-hoods (Plate 5) are vented by a fan operated by a two-horsepower motor. One hood may be shut off by a damper while its mate is in use. All hoods are adjustable as to height and position, and may be entirely removed and stored in the small cupboards at the two ends of the worktable, the vent-hole being covered by a small metal lid.

### STORE ROOMS AND OFFICES.

The plan here followed, which does away with separate laboratory and lecture room, leaves no space in the classroom for a teacher's desk or personal belongings, such as books, records, teaching aids, etc. Neither are there conveniences or room for the preparation of teaching material, nor for the unescapable "clearing up" which has to be done, even after the best of classes. There is also need for storage facilities in addition to those provided by the apparatus cases in the classroom. Considering the substantial saving made by utilizing one room instead of two for the work of a class, it is not unreasonable to urge the provision of special rooms to meet these special needs.

These plans provide at least one office for two teachers, and at least one preparation room for two classrooms. The offices are placed to secure good light, and may or may not be divided from the preparation room by a glass partition. They are furnished with built-in bookcase and filing cabinet. (Plate 2, Figs. 3 and 4.) The preparation rooms are equipped with cases, cupboards, drawers of various dimensions, sink and drying rack.

A small amount of reserve supplies and equipment may be stored here, as well as pieces of special apparatus; but this room is not designed to provide for all the reserve stocks necessary for the year's work, nor to house apparatus which is used in common by the whole department. The ill-smelling, dark, crowded storeroom of the old-fashioned laboratory afforded admirable opportunity for expensively bad housekeeping. The

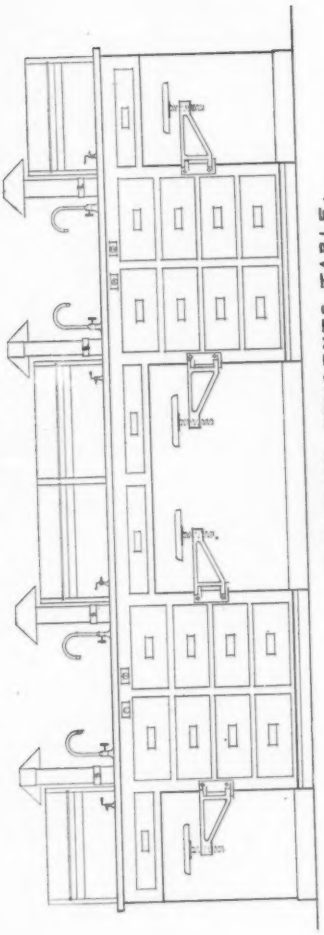
present plan contemplates a general school store room, under the charge of a custodian, and, adjacent to this and under the same charge, science department storerooms, in which will be kept reserve stocks of supplies, equipment and chemicals. The custodian keeps a strict account of the income and outgo of materials. An intercommunicating telephone system and an elevator, make it easy for the teacher to obtain any desired item.

The two science storerooms are in the shape of an L, with a fireproof sliding steel door between. The inner room has reinforced concrete floor and walls in satisfaction of the requirements of the fire insurance underwriters. One room of this character readily houses all of those corrosive and inflammable chemicals which have no place in the preparation rooms on the upper floors. In addition, it removes those dangerous chemicals from the immediate neighborhood of the pupils. Carboys of acid are placed upon a low platform in the middle of the room, while other chemicals are arranged in open cases around the walls. The outer room serves for the storage of all excess stocks. One wall of the outer room is fitted with bins of different sizes, fronted with riser boards, for the storage of various supplies, such as corks, stoppers, flasks, beakers, etc. The other walls have shelving for bottles, battery-jars, etc., and a special rack for glass tubing and rodding.

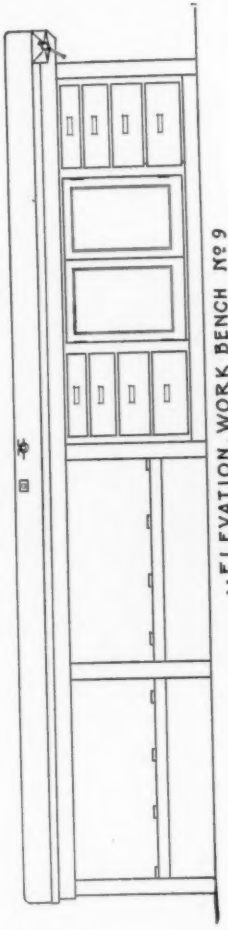
### Visual Education Provisions.

*Visual Education* may serve two important purposes in science teaching: (1) it may be closely integrated with the work of the class, serving as one of the classroom means utilized by the teacher in putting over a unit of subject matter, or (2) it may be employed as an extra-classroom means of stimulating interest and vitalizing the subject matter of the science course. Visual education in the science classes is carried on through the medium of (1) stereopticon slide projection, (2) motion pictures, (3) opaque projection, and (4) picture material from magazines and pamphlets.

Easy availability of the materials needed for the work must be a primary consideration in planning to use visual education as a classroom device. Otherwise, so much time is consumed, and the attention of the class so thoroughly distracted, that the teaching value is greatly reduced.



ELEVATION · STUDENTS TABLE ·
SCALE 1" = 1'
PLATE 5.



ELEVATION WORK BENCH No 9
SCALE 1" = 1'
PLATE 6.

The equipment of the science department should include a combined stereopticon-balopticon and a portable moving-picture projector. These should be mounted on movable stands to permit ready moving from room to room. Outlets for alternating current electricity have been installed on the work-table nearest the front of the rooms, so that connections with current source may be made easily and quickly. The demonstration materials case serves for the storage of slides and pictures for opaque projection. The rooms are darkened by means of heavy window shades fitted into a light trap carried on the window casings. The wall behind the sliding blackboard has been covered with a special preparation rendering it entirely suitable for all types of projection.

In carrying on visual education with larger groups of pupils a lecture room accommodating about one hundred pupils is necessary. The room should be equipped with tiers of raised seats, a high grade projection screen and a fireproof projection booth. Certain picture films, or sets of slides, may here be shown to large groups of pupils. The room may also be employed for lectures by teachers, pupils, or outside speakers, demonstrations by pupils, or science plays and pageants. Such a lecture room should be available to other departments of the school; in fact, it might well operate as the center of visual education in the school.

### The Science Shop.

One of the most important adjuncts to the science department of the modern junior or senior high school is the science shop. Each science classroom contains a work-bench equipped with a Toles quick-acting vise and drawer space for tools, nails, screws, bolts, etc. (See Plate 6.) Ordinary emergency repairs and simple construction work may be carried on here by either teacher or pupil, but for the accomplishment of projects involving construction or for the building of various pieces of apparatus the science shop fills a real need. In addition to serving as a place for the construction of such articles as mineral cases, mounting boxes, trellis frames, cold frames, animal houses, window boxes, bird houses, and paraphernalia for insect collections, the shop may prove useful as a field for such activi-

ties as taxidermy, the preparation of skeletons, the preparation of flowers for mounting, or the binding of pamphlets and books.

In our school plant the science shop has been placed in a very advantageous location, easily accessible to pupils and teachers from any of the classrooms. Extending across one entire side, under the windows, is a long work-bench, fitted with two Toles vises. Liberal drawer space has been provided below for the storage of small tools and construction materials, while above the bench and between the windows is a 30-inch riser of wood upon which the larger tools are hung. A small motor-driven lathe is eventually to be installed in the space provided for it on one side of the room. Partially completed construction projects are stored in the ample compartments of an open case located near the door opening into the corridor. Along the wall opposite the work-bench is a refrigerator connected with a floor drain-pipe, and a large wash-bowl with water-tap above.

### A Club Room.

In the present-day life of the high school the science club undoubtedly should hold an important position. By encouraging the formation and growth of science clubs one may make excellent capital of the gang instinct which is so strong in children of the secondary school age, and thus bring about an enrichment of the course of study on the "high-grade play level." In a large school a small room should be provided as headquarters for the various science clubs. Various exhibits of materials collected by the club members may be stored in cases, several of which should be provided in the room. The radio club will need an aerial on the outside of the building and a small room within for sending and receiving. This room could very appropriately belong to the science group. A dark-room should be available to the members of the camera club. Equipment for developing, printing, enlarging and coloring pictures is desirable.

### Science Garden.

The role of the outdoor laboratory, or science garden, in the work of the department is a very important one. Where such a plot is not available or cannot be properly equipped, definite modifications in the plans for the general science and biology

rooms are necessary to provide accommodations for living plants and animals within the classroom. Such accommodations are never satisfactory, however, and an outdoor laboratory is, in the opinion of the writers, an absolute essential. Where ground is not available conveniently near the laboratories, the roof may be utilized.[5] The space available in these plans is about 300′x120′, with southern exposure, enclosed on two sides by those wings of the school building which house the science department. The garden will have a pool, an aviary, animal houses (for rabbits, poultry, etc.) and a small conservatory, with a toolroom and workshop attached. The garden will be laid out to provide school garden plots for the seventh grade pupils, and experimental plots for the older classes; the whole to be bordered with shrubbery and vines and securely protected by a substantial fence.

## SUMMARY.

The points which the writers desire to present for special consideration in this paper, may be summarized as follows:

(1) Close co-operation between architect and teacher helps each to a better understanding of the other's problems. This co-operation can be brought about by the wise administration of a superintendent of schools who seeks to utilize in fullest measure the contribution which the classroom teacher can make to the development of educational theory and practice.

(2) Laboratory facilities are essential for any satisfactory teaching of the natural sciences throughout the secondary schools.

(3) These facilities have generally been more elaborate than necessary for the purposes of science teaching in the secondary schools, and more expensive than future school building programs, which must care for a greatly increased enrollment, can afford.

(4) The provision of separate laboratories and lecture rooms has increased this expense, and has at the same time diminished the flexibility of the classrooms and tended to accentuate an undesirable separation between class work and laboratory operations. As a means of overcoming this tendency, a combined laboratory-classroom is suggested. The plans here described are designed for a general purpose six-year secondary school, not for a technical or trade school.

5 The new Theodore Roosevelt High School in Oakland has included in its plans a science garden and animal yard on the roof.

# Co-operative Work in the Organization of Local Material for General Science Instruction
## Water Supply Systems.

*(Concluded)*

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OUTLINE.

I. Introduction.
II. Part 1. The Oakland, California, Water Supply System.
III. Part 2. The Water Supply System of Cleveland, Ohio.
IV. Part 3. The Water Supply System of Muskogee, Oklahoma.
V. Part 4. The Cincinnati Water Supply System.
VI. Part 5. The New York Water Supply System.

### Part V. The New York Water Supply System.

A survey of the aims of instruction for this unit of the course was made in the following manner. Sixty teachers were asked to read the published outlines for the Oakland, California, and Cleveland, Ohio, water supply systems. Each teacher then wrote a paper stating the aims of instruction. These papers were examined and a list of specific and general aims was compiled. The complete list, with the frequency of each, is given in Section 1 below, as the reader will observe there is a considerable range of opinion concerning the reasons for teaching this unit. Some of the objectives are rather unimportant, but the entire list is published for discussion and revision.

### Section 1. The Aims of Instruction as Expressed by Sixty General Science Teachers.

| I. SPECIFIC AIMS. | *Number of Teachers Reporting this Aim* |
|---|---|
| 1. Science, appreciation of | 28 |
| 2. Citizenship | 19 |
| 3. Engineering difficulties overcome | 15 |
| 4. Sewage, disposal | 13 |
| 5. Filtering plant, health | 13 |

6. Source of water ..... 2
   a. Advantages of pure water ..... 2
   b. Distance from consumer ..... 5
   c. Environment, control of ..... 1
   d. Free from contamination ..... 22
7. Habits.
   a. Accuracy ..... 1
   b. Cleanliness ..... 2
   c. Health ..... 1
   d. Honesty ..... 1
   e. Inquiry ..... 4
   f. Methodical procedure ..... 9
   g. Neatness in written work ..... 3
   h. Observation ..... 7
8. Appreciation of water as a valuable commodity ..... 1
9. Bacteriology ..... 4
10. Camping trips, methods of purifying water ..... 1
11. Conservation of forests ..... 5
12. Consumption of water, amount of ..... 4
13. Consumer's responsibility ..... 5
14. Cost of the water supply system.
   a. To the city ..... 1
   b. To the individual ..... 1
   c. Repair ..... 4
15. History of the system ..... 4
16. Efficiency of system ..... 1
17. Labor situation, men employed ..... 3
18. Maps, charts, graphs, reports, interpretation of ..... 2
19. Ownership, advantages of private and municipal ..... 5
20. Physiography of the community ..... 4
21. Pipes, miles of ..... 1
22. Plumbing, inspection of ..... 1
23. Population, future growth of the city ..... 5
24. Pressure for fires and residences ..... 3
25. Rainfall, relation to storage reservoirs ..... 1
26. Regulations, sprinkling lawns ..... 1
27. Sanitation ..... 10
28. Supply of water.
   a. Unnecessary waste of ..... 20
   b. Pure but not always satisfactory ..... 9
   c. Part of city supplied by present system ..... 2
   d. Suburban supply ..... 1
29. Vocational aspects of.
   a. Handing of tools ..... 2
   b. Reading the meter ..... 17
   c. Installation and repair of faucets, etc. ..... 19

II. GENERAL AIMS.
1. To give a general idea of the size of the undertaking..... 13
2. Advantages in vocational work ..... 1
3. To provide a good foundation for future scientific study... 1
4. Opportunity to those who do not continue science; fills needs of those who leave school early ..... 1
5. Stimulates more intensive study ..... 1
6. Transfer of training; well organized mass of useful information ..... 1

**Section 2. A Series of Ten Lessons Based upon the New York City Water Supply System.**

In considering the study of the water system of a very large city like New York, the immensity of the system itself will necessarily call for a very prolonged and thorough study. It is difficult to see how justice can be done both to the topic and the pupils if the teacher takes up this unit briefly and as a matter of form only. By this we mean that some teachers might teach the topic merely because it would be bad policy to leave it out. On the other hand, having decided not to leave it out, the teacher may not think it worth while to devote much time to the study of such a topic.

But what can be more important in the life of an individual than pure drinking water? If we stop to think of the part that pure water plays in the life of every person in the city, we realize that too much time can hardly be given to this unit. We justify the teaching of various scientific principles by showing their relations to everyday life. How much motivation would we need to interest the pupil in the study of the water supply of his city? Not much more than we need for the teaching of the care of the body and the prevention of disease.

An inspirational talk by the teacher will suffice to arouse the pupil's interest in pure water. A field trip, preferably one which will show the detail of the system, will astound the boy or girl by its magnitude and will spur him on to further investigation.

We are justified in taking time for this study because of the various scientific principles which are involved. For instance, a good opportunity is furnished for the study of such principles as are related to water pressure, gravity, meters, siphons, screws (study of faucets), formation of springs, distillation, filtration, etc. In this way the things are discussed as part of a great scheme. The practical applications are easily seen. Their concrete relationship to everyday life is evident.

**Lesson I. Introductory Lesson.**

1. Water as a physical and a chemical substance.
2. The composition of water. (As a demonstration to be done by the teacher, electrolysis would serve well here to show

concretely the composition of water.)

3. Water as a solid, liquid, and a gas.
4. What constitutes the New York water supply system?

**Lesson II. Trip to the Natural History Museum, New York City**

This trip is to be taken after the first lesson, that is after the pupil has been initiated into the study of the water supply system. The trip is so planned as to follow, as far as possible, the entire sequence of lessons. To make the trip something more than a pleasure excursion, it is recommended that the pupils answer the questions indicated in the plan, as they visit each exhibit.

a. *Food Exhibit.*
   1. What position does water hold in the composition of the various foods?
   2. In what foods does water predominate as a component part?
   3. Is the water present in the foods in the same state as the water found free in nature?
   4. Plan a diet which would give you a healthful well-balanced meal.

b. *Public Health Exhibit.*
   1. Sources of water.
      What are three important sources of water?
      What other sources of water can you think of?
   2. Growth in population.
      Has the growth in population in New York been rapid in the last 50 years?
      Which borough grew most rapidly?
      Which borough has grown most rapidly recently?
      How has this growth affected the evolution of the water supply system?
      How was water first conducted to the houses?
      What were the water mains made of?
   3. The Catskill Aqueduct.
      How much money is spent by the city yearly to maintain its water supply system?
      Where are the four large reservoirs of this system located?

What system preceded the present one?
How far does the water travel?
What kind of mains are used today?
Are the mains cleaned?
How is the necessary water pressure obtained?
What two systems are there which maintain the pressure?

4. Purification of water.
   What is an aerating plant?
   How does water shoot up through the nozzles?
   What are three ways of obtaining pure water?
   How is water chlorinated?
5. Water and disease.
   What disease is carried chiefly by water?
   Are the deaths from this disease on the increase or decrease?
   What years brought great epidemics?
   What insect carries this disease?
   What are its breeding places?
   How can you help destroy the insect and its breeding places?
6. Sewage.
   What do you mean by sewage?
   How many ways are there in which sewage can be destroyed?
   How is sewage conducted through the city?
   Is water coming from our chief source of supply used in the sewage system?
   How can sewage pollute a good water system?
   What is a septic tank?
   Is New York's sewage problem well taken care of?
   Why do you think so?

The answers to all of these questions are gotten from the exhibits and from the teacher's explanation. A written report is to be required from each pupil, either in the form of direct answers or in the form of an essay which must follow the above outline and in which all questions must be discussed.

**Lesson III. Water and Its Uses.**

Suggested experimental work which can be used in connection with the study of the New York Water Supply System will be found in Section 3 of this outline.

a. Water and its relation to the human body.
   1. Perspiration.
   2. Tears.
   3. The blood.
   4. Digestion.

b. Water in our food.
   Show the composition of some of our most important foods, to illustrate the occurrence of water in typical foods.

c. Water power.
   1. Water power.
   2. Industries that require a large volume of water.

d. Water in our homes.
   1. Cooking.
   2. Bathing.
   3. Drinking.
   4. Spraying, etc.

e. The occurrence of water in nature and how it affects our homes.
   1. Rain.
   2. Snow.
   3. Humidity, etc.

f. Water and the community.
   1. Fire.
   2. Sewage.
   3. Drinking fountains.
   4. Flushing the streets, etc.

This lesson is not to be solely in the form of a lecture by the teacher. The pupils are to come to the class-room prepared to discuss the uses of water, as a result of previous observations and readings which have been assigned by the teacher. The lesson will then be conducted by the pupils as well as by the teacher. The local newspapers should be referred to in order to get information—whether social, political or economic—concerning water. The recent water supply problem which was

due to the presence of synura in the water, was discussed extensively in the newspapers. This excellent material is useful in the science room.

**Lesson IV. Sources of Water Supply.**

Assignments should be made to three or four groups of pupils to bring in written discussions on the sources of water. These should be read in class and criticized by the teacher and the pupils. The salient features of each report are to be noted.

a. Rain as a source of water.
   Why is this not a reliable source?
b. Rivers as a source of water.
   Is this a dependable source?
c. Lakes.
   Is lake water always pure?
d. Springs.
   How are springs formed?
   Do springs furnish water all summer?
e. Artesian wells.
   Is this a good source? Why?
   Can this system be used extensively?

Which of the above sources is most practical for a community requiring a very large water system?

**Lesson V. The Water Supply Problem of a Big City.**

In the previous lesson the teacher should have asked two or three pupils to bring in a report showing the growth of population in New York. This report will show the growth during the past one hundred years. When the results are reported to the class the teacher should supervise the construction of a graph showing this growth in population. The graph can be referred to now and then during the study of the water supply system.

a. Has the present system always existed?
b. Does a change in the population necessitate a change in the water system?
c. By means of graphs and other exhibits show the growth of Manhattan Island.
d. Show the rapid and recent growth of Brooklyn.

e. Show how this growth called for a change in the water supply system.
f. What is the probable cost of water per capita?

**Lesson VI. The Catskill Aqueduct.**

Turn on the faucet in the laboratory. Show the force with which the water rushes out. Ask the following questions:

a. What is the source of water?
b. Compute the approximate distance that the water travels.
c. How does it get to Queens and to Richmond?
d. Types of water supply systems.
   1. The gravity system.
   2. The pumping system.
   3. The combination system.
e. Illustrate the transmission of water pressure by a demonstration experiment.
   1. Which of the two systems is used in New York?
   2. Which is better?
   3. Which is the more expensive?
f. These questions should be discussed thoroughly by the class. The spirit of debate will carry the discussion to the civics room. An assignment can be made here for the next lesson, which is to be a continuation of this.
   1. What systems are in use in other cities?
   2. Trace the development of our present system.
   3. Make a diagram of your house and show how the water from the street gets to your kitchen sink.

**Lesson VII. The Catskill Aqueduct in Detail.**

a. Why the project was undertaken.
b. The time required to build the aqueduct.
c. Money expended in construction work.
d. Length of the aqueduct.
e. Schoharie reservoir.
f. Ashokan reservoir.
g. Kenisco reservoir.
h. Hill View reservoir.
i. The aqueduct north of the city.
j. The city tunnel.

k. Silver Lake reservoir.

l. The siphons.

A few capable pupils may be asked to make a large cross-section diagram of the entire aqueduct. Working models of siphons and the various sections of the aqueduct can be constructed in the laboratory.

**Lesson VIII. The Measurement of Water.**

Discuss why water must be measured. Water is sold by:

a. Flat rate.

b. 1000-gallon method.

The measurement method is the one which will lead to the study of the water meter. It is advisable for the teacher to get a meter and study it with the class. If this cannot be done, then the meter must be studied by means of diagrams. The importance of the study of the measurement is obvious. The tremendous cost of building and maintaining an aqueduct necessitates some form of remuneration to the city. The present rent crisis will open an interesting field for discussion, since the taxes which are paid determine to a large extent the rent asked for living quarters. Pupils can find the appropriation which the city makes for the maintenance of water supply in the budget report. Let the pupil estimate the cost of the water which he uses each year.

**Lesson IX. Purification of Water.**

a. Discuss ways in which water may be polluted.
What diseases are carried by water?

b. Methods of purification.

1. Aeration.
2. Chlorination.
3. Coagulation.
4. Filtration.
5. Distillation.

The problem of pure water is a very important one and the pupil realizes this. Specimens of different kinds of water should be analyzed by the teacher. The teacher can also give

a very interesting talk on the penalty which is paid by a community that does not exercise absolute care concerning its water.

**Lesson X. Sewage.**

a. What is done with waste water?
b. Discuss the possibility of polluting good water with sewage.
c. Is the sewage problem as important as the water problem?
d. What is sewer gas?
e. Show how to test for sewer gas?
f. What is the trap in your sink for?
    1. Cesspools.
    2. Septic tanks.
    3. Contact filter bed.
g. Discuss the action of bacteria.
h. Distinguish between pathogenic and non-pathogenic bacteria.

**Section 3. Experimental Work Which Can be Used in Connection with the Study of the New York Water Supply System.**

a. Why is copper sulfate used in reservoirs?
b. How does a siphon work?
c. What is the difference between hard and soft water?
d. Are samples of water drawn from faucets in different parts of New York at the same time of day alike?
e. What is chlorine gas, and why is it used in the purification of water?
f. What kinds of plants and animals will a microscope reveal in drinking water?
g. What kinds of soaps and water softeners are used about the home?
h. Why are pressure tunnels necessary in the Catskill Aqueduct?
i. How is water distributed by means of large and small pipes?
j. What is an aerator and how does it work?

k. Why does a shale or sandstone region usually furnish a "softer" water than a limestone region?
l. Does water change in volume when it freezes?
m. Does water always boil at the same temperature?
n. Is it cooler in New York than in Chicago during the months of July and August?
o. How does the New York City Water Department make the various chemical tests on the water?
p. Why does the ground become so dry under the trees in Central Park in the summer time?
q. What percent of water is found in such foods as strawberries and watermelons?
r. Is there a definite relation existing between the quality of water supplied to a city and the health of the citizens?
s. What is water composed of?
t. Why is a mixture of ice and salt used in the manufacture of ice cream?
u. Why is ice placed in the top of the refrigerator?
v. Does ice always melt at the same temperature?
w. How does a force-pump work?
x. How is a water meter used to measure the amount of water supplied to a building?
y. What are synura?
z. What is the cost of a leaky faucet?

**Section 4. Suggestions for Home Work and Special Reports by Individuals or Groups.**

A. Suggestive Home Problems.

a. Diagram the water faucets and water pipes in the kitchen of your home. Could the plan be improved?
b. Make a cross-section drawing of the different types of water faucets in your home and explain how each type works. How may these faucets get out of order? How are they repaired?
c. Do you use home filters? Diagram one and explain how it works.
d. Show a top view of the kitchen sink with faucets. Is the sink really convenient? How high is the top of the sink from the floor?

e. Study the operation of the tank of the toilet in your home. Where is it likely to get out of order? How repair it?

f. Diagram the different types of traps that are used in your home. How are these traps cleaned? Why have these traps?

g. Keep a record of the ice used during a period of two weeks. Obtain the average daily temperatures for this period. Make a graph for each.

h. Draw a diagram for your refrigerator. Show the ice chambers, the food chambers, and the path of waste water from ice to drain pipe. Where does your ice come from?

i. How does a home ice-machine work?

j. Keep a daily record of the rainfall for one month. How does this value compare with the average value for this locality?

k. Which of the following are used for carrying hot water in your home? Cold water? Waste water?

a. Brass. c. Wrought iron. e. Steel.
b. Lead. d. Lead-lined steel.

l. Diagram a pressure-cooker and explain how it works.

m. How high above the street is the water-tank on your apartment building? What kind of a pump is used to fill it? What water pressure is necessary to lift the water to this height? Make a diagram showing all of these essential facts.

n. Is there a water meter in your home? Read the meter and find out how much water is used in a week. Find the cost per month.

o. Keep a record of the amount of water (gallons) used in one day for your home. How does this compare with the daily per capita consumption in New York? What is the cost of this amount of water?

p. Prepare a list of the uses of water that you see in one day. What other uses are made of water in New York?

q. Consult the newspapers for the past year and write an account of the synura which made the New York City water have an unpleasant odor.

r. How does the cost of water in New York compare with

that of other large cities? Make a bar diagram to show these costs.

s. What is the typhoid fever death rate in New York now? What was it 20 years ago? Make a bar diagram to show the change.

B. Suggestive Topics for Special Reports.

a. What is the work of the New York Department of Water Supply, Gas, and Electricity?

b. How did New York obtain water before the present system was built?

c. What is the Catskill system, and in what parts of the city is the water used?

d. What constitutes the Croton system? Where is the water used?

e. Is the water that is supplied to New York of the proper quality?

f. How is water wasted in New York?

g. A study of water pressures in various parts of New York City.

h. Can you make a time and volume study of the water used in your home by reading the water meter every hour of the day. Make a graph to show the results.

i. How is the distributing system kept in good repair?

j. How are fires controlled in the tall buildings?

k. How much revenue is collected during the year?

l. Prepare a graph showing the annual rainfall in the Catskill and Croton watersheds.

m. Prepare a graph to show how the Catskill water compares with other waters supplied to New York in per cent of impurities.

n. What has been the average daily consumption of water since 1910?

o. What is the per capita consumption in six or eight of the chief American cities?

p. Prepare a graph showing the average amounts of chlorine used in the chlorinating plants.

q. What are the chief features of the water supply system of Cincinnati? Chicago? Cleveland? Los Angeles? Oakland, California? Philadelphia? Gary, Indiana? Columbus, Ohio? Altoona, Pa.?

**Section 5. Samples of High School Students' Work.**

A. Class Project on The Construction of a Model of the Catskill Aqueduct.

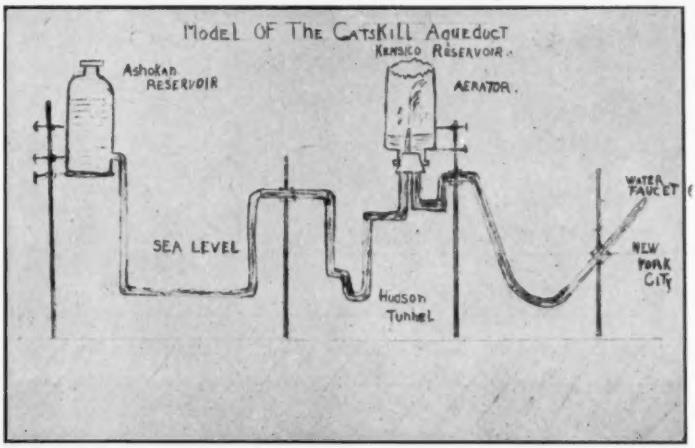


**Fig. 1.** This drawing of a working model of the Catskill Aqueduct was made by an eighth grade boy.

B. A Report on a Visit to the Natural History Museum.

A VISIT TO THE NATURAL HISTORY MUSEUM.
Susanna. Age 15 years. 9th Grade Class.

"The purpose of our visit was to investigate the public water supply exhibit of New York City, the topic under discussion in class. The information was obtained from a large relief map of the entire system, set in a glass-enclosed table. We located and discussed the following: The Esopus Creek with the surrounding watershed, and Schoharie watershed, which is now under construction. The Ashokan Reservoir alone covers a larger area than that of Manhattan Island. The next large reservoir that we located was the Kensico Reservoir, about three miles north of White Plains. We traced its course south to the Hillview Reservoir in Yonkers. A large green area represented the Croton system. It was interesting to note the immense areas of water used to supply the comparatively small Manhattan Island.

C. Some Samples of Drawings. (Figs. 2, 3 and 4.)

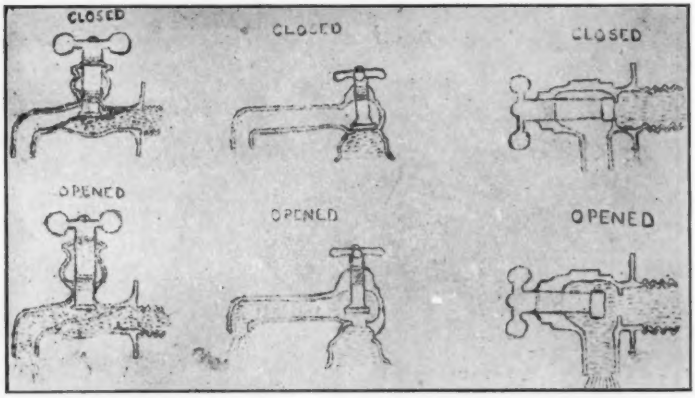


Fig. 2. Types of water faucets, as drawn by an eighth grade boy.

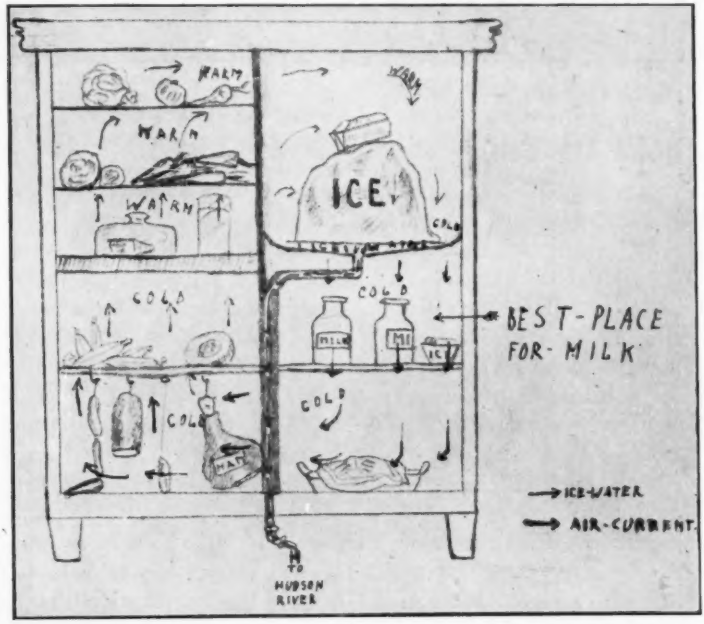


Fig. 3. The refrigerator, as explained by a pupil in the ninth grade.

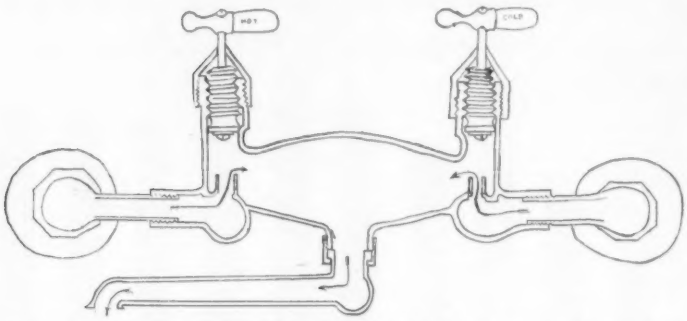

Fig. 4. A new type of water faucet for the kitchen sink, as drawn by an eighth grade boy.

We then examined various kinds of water: namely, swamp, well, river, and rain water. Each kind of water was in a separate compartment, which contained a cube representing relatively the amount of dissolved material in each. It was surprising to note that well water contains respectively more solids than either swamp or river water. Rain water is the purest.

When we drink a glass of water, we little realize the number of impurities it contains, most of which are not in the least harmful. These little germs were highly magnified, and received our special attention.

The next thing we examined was the amount of rainfall of the different cities. The rate of rainfall in New York is about forty-seven inches per annum.

The typhoid germ has been found in water; so we examined the germ of typhoid magnified twenty-five thousand times. If there are cases of typhoid in your neighborhood, it is a good plan to boil all water used in your home. A brief study of the benefit water receives from storage in the reservoirs of the system, proved that if water could be stored for a period of four weeks, meanwhile receiving a bleaching in the sun, it would be almost entirely free from typhoid germs.

The water is purified by many processes, chlorination and aeration are illustrated in the museum. A large room is devoted to the study of the water supply, not only of the present, but also of the past; and this exhibit affords opportunities for a study of the future needs of New York."

August 3, 1922.

D. Some Charts that Were Prepared by High School Students.

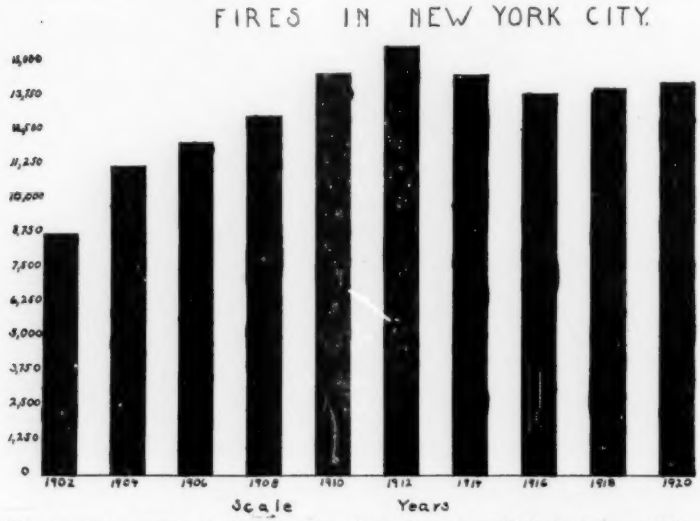


Fig. 5. The growth of fires in New York City, as exhibited by an eighth grade boy.

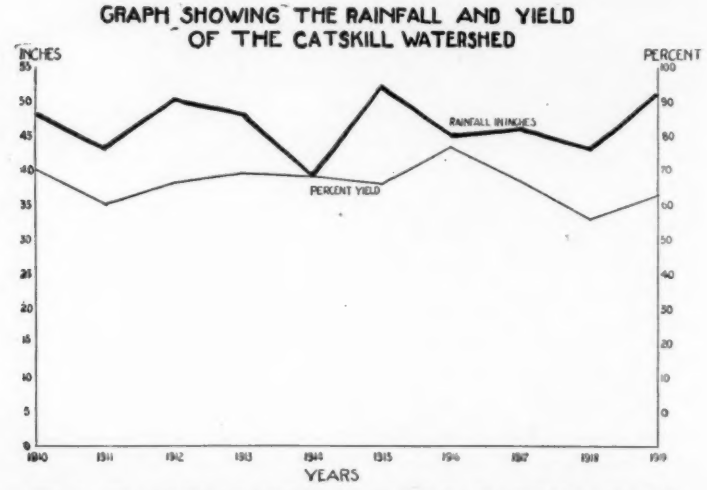


Fig. 6. The relation of rainfall to "run-off" for the Catskill watershed.

E. Laboratory Notes.

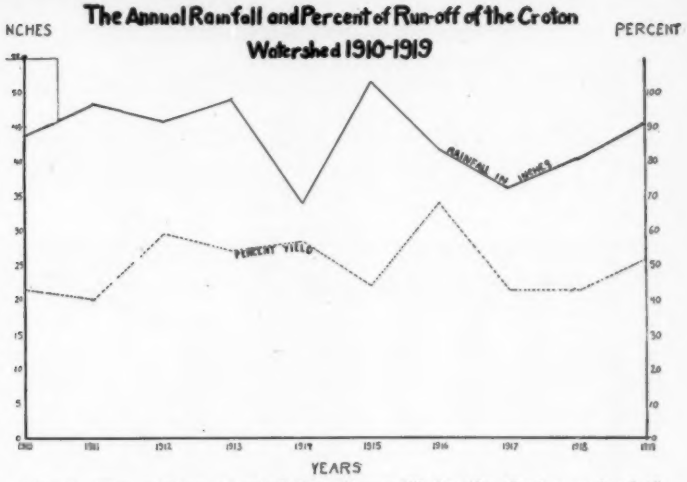


Fig. 7. The relation of rainfall to "run-off" for the Croton watershed.

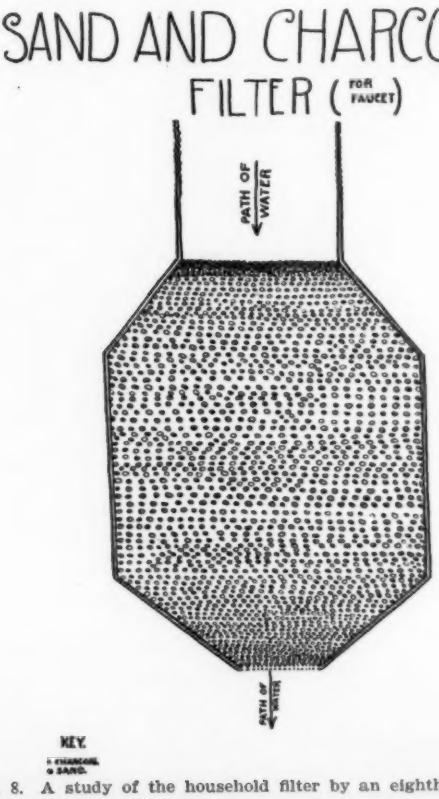


Fig. 8. A study of the household filter by an eighth grade girl.

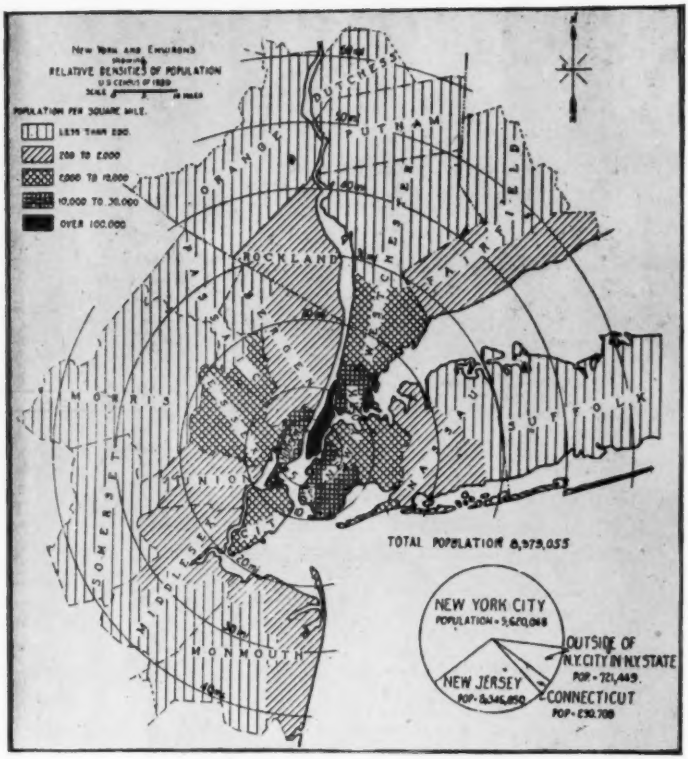


Fig. 9. A sample from the scrap-book.
(A clipping from The New York Times.)

# POLLUTION OF CITY'S HARBOR GROWING PERIL TO HEALTH

## *Daily Volume of Discharge Increasing Faster Than Waters Can Assimilate It—Plans for Solution Prepared at Great Expense, but They Still Lie Idle.*

By GEORGE A. SOPER,
Formerly Member of the New York Bay Pollution Commission and President of the Metropolitan Sewerage Commission.

AFTER having been apparently forgotten for some years there are signs that the pollution of New York Harbor may again receive official attention. The Chamber of Commerce of the State of New York, which took a leading part in bringing about the construction of the first rapid transit subway, the Catskill water supply and the Port Authority, has been inquiring into the state of the harbor waters with a view to the adoption of remedial measures. On Nov. 3, 1921, the Chamber passed a resolution urging municipal authorities in New York and New Jersey to take such steps as might be necessary to bring about a study of the matter, and on March 30, 1923, the Merchants' Association sent a letter to Mayor Hylan calling attention to the polluted condition of the harbor.

Seventeen years ago these two powerful business organizations, under the leadership of the Chamber, united with the Board of Trade and Transportation, the Maritime Exchange and the Produce Exchange, representing all the trade and commerce of the port, in a successful effort to induce the Legislature to provide for an investigation of the question. Mayors McClellan, Gaynor and Mitchel in turn gave their approval to the undertaking and the Board of Estimate and Apportionment voted $265,000 to pay expenses.

For eight years the subject was under official study. The result was a set of plans [illegible]

the elements of the problem have been forgotten. New elements have been introduced. There has been an advance in sanitary science and in standards of decency and health. Progress has been made in sewage disposal. The cost of labor and materials has greatly increased. The population has grown and with it the evils of pollution. Relations with New Jersey, which is naturally a partner in the harbor pollution problem equally with New York, have changed very much for the better.

### Would Start Work Anew.

What is wanted now is to have the planning so auspiciously begun extended and brought up to date. Due account should be taken of what has happened in the last nine years. There should be a re-examination and revision of the plans, an extension of this work to include metropolitan New Jersey as well as New York, the complete working out of a scheme of administration for the construction and maintenance of the necessary works and of a suitable system of financing the system.

At first sight it may seem a simple matter to stop pollution. But it is a question full of engineering, legal and financial difficulties. Sewage cannot be kept entirely out of the harbor unless it is taken somewhere else, and there seems nowhere else to take it. What is to be done with this volume which, by 1940, will amount to 1,700,000,000 gallons every twenty-four hours? It cannot be put upon land, for there is not enough unoccupied land within reasonable distance to receive it. [illegible] cannot all be carried out to sea [illegible]

Fig. 10. A great problem which must be solved.
(A clipping from The New York Times.)

# 3-FOOT MAIN BURSTS, SUBWAY MENACED

## New Tie-Up on Lexington Avenue Line at 26th Street Narrowly Averted.

## GATEVALVES END GUSH

## Basements of Madison Square Garden and Other Buildings Inundated.

The bursting of a thirty-six-inch water main at Fourth Avenue and Twenty-sixth Street late last night resulted in the flooding of streets for three blocks south, the pouring of thousands of gallons into the Lexington Avenue division of the subway at that point and the blocking of traffic in the immediate vicinity.

At 1 o'clock this morning Interborough officials said that the rapid rise of the water at Twenty-fourth Street and Fourth Avenue would probably necessitate shutting off of power and the halting of traffic in the subway at that point, but thirty minutes later a valve [illegible] Cooper Square and a bigger gate [illegible] Fortieth Street and [illegible]

Fig. 11. Who is responsible for the maintenance of the system? (A clipping from The New York Times.)

## Section 6. A Selected Bibliography on the New York Water Supply System.

This bibliography of books about the New York City water supply system was compiled from various sources in and about the city. The Main Branch of the New York Public Library, 42nd Street and Fifth Avenue, and the Brooklyn Municipal Library were used as main sources. Hundreds of books were found, discussing all stages and phases of this system of water works. Among them were books, magazines, pamphlets and newspaper clippings dating from 1800 to the most recent publication dates. Most of this printed matter, though valuable in itself, was found of little use in making a practical and workable bibliography to accompany a set of lesson plans on the New York water supply system. The most authentic, practical, and recent publications, which might serve as reference reading in connection with the lesson plans, were selected. The most pertinent books were more thoroughly reviewed, indexed on a card catalogue, and the contents noted.

I. EARLY HISTORY OF THE NEW YORK WATER SUPPLY.

*Author.* *Title.*

Cuyler, Thurston Carlyle.
The Croton Watershed to the City of New York; As it was, As it is, and As it will be. Address delivered before meeting of Insurance Society of New York, March 19, 1914.

Hall, Edward Hagaman.
The Catskill Aqueduct. American Scenic and Historic Preservation Society, Annual Report, Albany.

New York City Public Library Bulletin.
An Exhibition Illustrating the History of the New York Water Supply, 1639-1917. N. Y. Pub. Lib. Bull., 1917, 4°, v. 21, 407-412.

White, Lazarus.
The Catskill Water Supply of New York City. J. Wiley and Sons, 1913.

II. CONSTRUCTION.

Catskill Water Works and Ashokan Reservoir Dams. Engineering News, May 9, 1907.

Catskill Water Supply, General Description. Board of Water Supply of the City of New York (report), April, 1922, p. 1-39.

Donaldson, F.
Shaft Sinking, Catskill Aqueduct. Mines and Minerals, April, 1909.

Flinn, A. D.
Under City Tunnel for Delivery of Catskill Water to Distributing Mains, New York City. Harvard Engineering Journal, January, 1911.

Hogan, John P.
The Narrows Siphon from Brooklyn to Staten Island. Ameri-

can Water Works Association Journal, Baltimore, 1920, v. 7, p. 394-405.

Richards, Frank.
The Pumping Problem in Morningside Park. Compressed Air Magazine, Easton, Pa., 1916, v. 21, p. 7930-7944.

Sanborn, J. F.
Some Geologic Features Affecting the Catskill Water Supply. Harvard Engineering Journal, June, 1908.

Smith, J. Waldo.
The New York Water Supply. Abstract of a Report of Chief Engineer of Board of Water Supply. Engineers Record. Current News, Oct. 14, 1905.
The Municipal Water Supply System of the City of New York. A General Description. Dept. of Water Supply, Gas, and Electricity. May, 1920, p. 5-32.

Wegman, Edward.
Construction of the New Croton Dam. American Society of Engineers. Nov., 1920, p. 384-422.

III. PROTECTION AND PURIFICATION.

Babbit, Harold Eaton.
Catskill Water Supply. A general description. Board of Water Supply of the City of New York. April, 1922, p. 29-39.
Chlorinating the Water Supply of Greater New York. Engineering News, N. Y., 1916, v. 76, p. 438-440.

D'Alier, William L., and staff of Sanitary Corporation of New York City.
Sanitation of Cities. De Vinne Press, 1921.
Filtration of the Croton Water Supply. Bulletin of the New York City Water Supply, Gas, and Electricity Dept., N. Y., 1913.

Fuller, George Warren.
The Croton Water Supply, Its Quality and Purification. American Water Works Association Journal, v. 1, No. 1, p. 135-187.

Hale, Frank E.
The Safeguarding of the Water Supply of New York City. Mining Engineers' Journal, New York, 1919, v. 5, p. 85-123.

Hale, Frank E.
Development of Sanitary Safeguards of New York City Water Supply and Its Relation to Typhoid Fever and Other Diseases. Mining Engineers' Journal, N. Y., 1921, v. 7, p. 30-65.

Hills, Nicholas S. (the younger).
Sanitary Conditions in Their Relation to the Water Supply in the Vicinity of New York. American Institute of Chemical Engineers, N. Y., 1911, v. 3, p. 374-384.

New York City Water Department.
Rules and Regulations for Protection of the Water Supply from Contamination. New York, 1917.
Sanitary Problems of Catskill Aqueduct. Engineering Record, May 6, 1911.
Sand Filters at Oakland Lake, L. I., N. Y. Engineering Record, N. Y., 1910, v. 62, p. 348.

IV. CIVIC PROBLEMS.

Brush, W. W.
Utilization, Conservation, and Sufficiency of the Water Supply of the City of New York. Mining Engineers' Journal, N. Y., v. 6, p. 128-143.

Brush, W. W.
Notes on Water Waste Prevention Work in New York City. Journal of New England Water Works Association, v. 29, No. 3, Sept. 1913.
Memoranda in Support of Bills Relating to New York City Water Supply. New York, 1901.
The Regulation of Private Water Companies in New York City. Journal of New England Water Works Association, v. 31, p. 550-574, 1917.

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## Book Reviews

*Civic Science in Home and Community*—George W. Hunter and Walter G. Whitman—528 pages—400 illustrations—$1.60—American Book Company.

This is a one-volume edition of *Civic Science in the Home* and *Civic Science in the Community*, for those schools which are able to give but one year to general science. It lists fifty projects, gives directions for numerous demonstration experiments, has many important score cards, suggests science problems, and offers a valuable bibliography. The topics covered are: science in the home; good health in the home, including air, water, food, wastes, and health habits; heat in the home, fuel, heating devices, and fire hazards; light in the home, types of lighting, our eyes; helpful home equipment, simple machines, electricity; recreation, photograph. heavenly bodies; advantages of the community; geological story; weather; water, water power, irrigation, forestry, water supply; community care of citizens, safeguarding food supplies, fighting disease, street lighting, police and fire protection, education; transportation on land, on water, in the air, good roads, automobile; communication, telegraph, telephone, radio; home and community gardening; improvement of life on the earth, plants, animals and man.

*New Essentials of Biology*—George W. Hunter—464 pages—fully illustrated—$1.68—American Book Company.

This book is based on principles which underlie not only biology but organized society as well. The purpose is an understanding of man. The various units of study deal with the functions of living things as they relate to man, and the physiological principles are finally applied to man himself. It has fourteen chapters dealing chiefly with plant life. Eight chapters discuss animal life, and eight chapters are devoted to man. These last eight chapters are: Man—a mammal; food and dietaries; the blood and its circulation; respiration and excretion; the nervous system and organs of sense; good health and how to keep it; health and disease; a chapter on civic biology. Throughout the text numerous problems are suggested, and many references are made to the laboratory manual for the solution of the problems. Each chapter has a brief summary and a list of problem questions and references. A helpful glossary is found at the end of the text.

*General Science*—Garfield A. Bowden—634 pages—334 illustrations—P. Blakiston's Son and Company.

The number of general science texts embodying the project idea is increasing. This book, which is just published, is one of the latest arrivals. The subject matter is divided into nine units: heat, air, water, light, energy, life, plants, simple organisms, man and improving human life. Most of these units are subdivided into several chapters. Each chapter opens with a statement of the object of the study. Text matter and experiments follow and the chapter ends with a long list of projects. Hardly a pupil can fail to find some interesting project in these suggested lists. "The purpose of each study is to bring about a natural development of interest, appreciation and power." Hygiene topics are introduced in accord with the recommendation of the Committee on Reorganization of Science. The book is an interesting one, well written, a trifle large, perhaps, but on the whole well adapted to Junior High pupils.

*Biology in Home and Community*—Gilbert H. Trafton—604 pages—514 illustrations—The Macmillan Company.

This is a high school biology text, which has for its basis the relation of plant and animal life to man's welfare. The work is divided into five parts, namely: introduction, domesticated life, wild life, human biology, and general biology. The text is well supplemented by problems, projects, summaries and references. The appendix contains a brief account of five famous biologists and a list of reference books for the high school library.

*Elementary Organic Chemistry*—W. H. Barrett—366 pages—29 cuts—$1.50—Oxford Unnversity Press, American Branch, N. Y. C.

When we read that there are today nearly two hundred thousand compounds of carbon we realize a little better the enormous scope and importance of "organic" chemistry. In this book we are led through simple compounds and processes to the highly complex ones. There are twenty-nine chapters which treat the important groups of organic compounds, giving preparation, properties, structures, and various relations one to another. It is a thoroughly good, up-to-date, elementary text covering carbon compounds.

*Plane and Solid Geometry*—Revised Edition—W. B. Ford and Charles Ammerman—384 pages—Illustrated—The Macmillan Company.

A number of changes and additions which experience has shown to be desirable, have been made in this edition. The text is particularly rich in its exercises and miscellaneous exercises. Applications of geometry to practical life problems are given special emphasis. The book includes a brief sketch of the history of geometry and contains an appendix of valuable tables.

*Plant Physiology*—Vladimir I. Palladin—360 pages—173 illustrations—$4.00—P. Blakiston's Son and Company.

This second edition was edited by Burton E. Livingstone of Johns Hopkins University. This is an authoritative college text covering these topics: assimilation of carbon and energy by plants; assimilation of nitrogen; absorption of ash constituents; movement of materials in plants; material transformation, fermentation and respiration; growth, internal and external; control of growth; movements of variation, development and reproduction. A valuable feature of this edition is a summary at the end of each chapter.

*The Menace of Morphine, Heroin and Cocaine*—M. Flowers and H. R. Bonner—48 pages—paper covers—25 cents—Narcotic Education Association, Pasadena, California.

The fact that "the United States uses more opium per person than any other nation in the world," is evidence that there is need of information and education to combat this state of affairs. This little pamphlet gives the essentials of what every man, woman and child in the country ought to know. It is well adapted for use in schools and clubs.

*The Animal and Its Environment*—L. A. Borrdaile—400 pages—426 illustrations—$5—Oxford University Press, American Branch, New York.

This book was written in response to the need of a systematic survey of the relations of the individual animal organizations to their surroundings. The scope of the work is best indicated by the contents which follow: the organism as an object in nature; physical factors which affect the lives of animals; special relations between animals and plants; relations between animals of different species, between the same species; the relations between the sexes; faunas; faunas in the sea; fresh-water faunas; land faunas; migration; internal parasites; influence of surroundings upon the animal organization. The general reader, as well as the student, will find much to interest him in the discussion of these topics. Illustrations are particularly fine, and include a number of colored plates.

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## Science Articles in Current Periodicals

AERONAUTICS

The fastest fighting plane in the world. Lit. Dig. 77:2:48. Apr. 14, 1923.

Shall we really fly without motors? Ernest Color. Ill. Wld. 39:51. March, 1923.

ATHLETICS

Women a close second to men. Pop. Sci. Mo. 102:3:63-64. March, 1923.

ATOMS

The atom a miniature solar system. Ill. Lit. Dig. 76:12:23. Mar. 24, 1923.

AUTOMOBILES

Which anti-freeze solution? J. E. McDowell. Ill. Wld. 38:899. Feb. 1923.

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BACTERIA

Our smallest toilers. Ill. Harry A. Mount. Sci. Amer. 128:170-171. Mar. 1923.

BURBANK

Burbank's plant creations to be preserved. Raymond Jurade. Pop. Mech. 39:591. Apr. 1923.

Children can be improved like plants—says Luther Burbank. Harry H. Dunn. Ill. Wld. 39:22. Mar. 1923.

My greatest discovery in fifty years. Luther Burbank. Pop. Sci. Mo. 102:4:55. Apr. 1923.

CANALS

The Welland Canal. Ill. G. F. Paul. Pop. Mech. 39:697. May, 1923.

The New Orleans Canal Lit. Dig. 77:2:24. Apr. 14, 1923.

CANNING

Value of boric acid in fruit preservation. Max Levine. Jour. Home Econ. 15:64-70. Feb. 1923.

CAVES

Science opens wonder caves. Robert E. Martin. Pop. Sci. Mo. 102:3:60. Mar. 1923.

CHINA

A thousand miles along the Great Wall of China. Ill. Adam Warwick. Nat. Geog. Mag. 63:113-143. Feb. 1923.

CISTERN

Cistern made of vitrified clay pipe. Ill. Lewis Davis. Pop. Mech. 39:453. Mar. 1923.

CITY PLANNING

The citè-jardins Lyons and Rheims. Edith E. Wood. Amer. City. 28:228-23. Mar. 1923.

COLOR

The latest in color harmony. William R. Remicke. Sci. and Inv. 10:966. Feb. 1923.

COMBUSTION

Combustion of coal in boiler furnaces. M'Kean Moffitt. Amer. City. 28:153. Feb. 1923.

COOKING

Relative cost of gas and electricity. Martha Dresslar. Jour. of Home Econ. 15:71-80. Feb. 1923.

EARTH

What is inside the earth. Ill. E. E. Free. Pop. Sci. Mo. 102:2:27-29. Feb 1923

How our earth was formed. Ill. E. E. Free. Pop. Sci. Mo. 102:4:25-26. Apr. 1923.

How the earth is kept in balance. M. Cook. Ill. Wld. 39:376. May, 1923.

Concerning the age of the earth. Ill. H. V. Hilker. Sci. Amer. 128:256. Apr. 1923.

EARTHQUAKE

Where earthquakes come from Cur. Opin. 74:218. Feb. 1923.

ELECTRICITY

Prevocational work in boy's clubs. W. F. Perry. Ind. Ed. Mag. 24:242. Feb. 1923.

Is your future in electrical engineering? William F. French. Ill. Wld. 39:70. Mar. 1923.

Principles and construction of an electrolytic rectifier. H. M. Swezey. Radio News. 4:1643. Mar. 1923.

# Have You Seen

THE

# CATALOG

WITH

THE

# GREEN CLOTH COVER

?

Home battery charger. C. J. Fitch. Prac. Elec. 2:212 and 222. Mar. 1923.

Static electricity—the outlaw. M. McCabe. Prac. Elec. 2:202. Mar. 1923.

Electrons, electric waves, and wireless telephony. J. A. Fleming. Radio News. 4:1614, 1778 and 1937. Mar., Apr. and May, 1923.

EYESIGHT

Computation of partial loss of vision. William Mehl, M. D. Nation's Health. 5:233. Apr. 1923.

FIRES

Curious causes of gasoline fires and gas explosions. A. H. Gill. Indus. & Eng. Chem. 15:140. Feb. 1923.

FIRE PREVENTION

Jumping Jack—fire prevention clown. Amer. City. 28:159. Feb. 1923.

FLOWERS

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